An ecological study of barley growing under three contrasting regimens of farm management

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AN ECOLOGICAL STUDY OF BARLEY GROWING UNDER THREE CONTRASTING REGIMENS OF FARM MANAGEMENT

By

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TO MY PARENTS.

The results in this thesis are entirely my own work, excepting that some of the analytical work has been done in cooperation with Mr. M. J. Parsons. It has not been accepted for any degree, and is not being submitted for any other degree.

A. J. Basahy.

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ABSTRACT

Using barley (Hordeum vulgare L.) as a phytometer, comparisons were made of the three systems of farm management (Organic, Mixed and Stockless), maintained as a long-term experiment by the Soil Research Association (Pye Research Centre) at Haughley in Suffolk. Special attention being paid to the geochemicals of the crops/soil system.

Significant differences were indicated between both 'total' and 'available' geochemicals of the three soil systems. The differences of available geochemicals are undoubtedly related to the differing long-term management, especially the continuous and predominant use of organic manures and mulches on both the Organic and Mixed systems. The unexpected differences in total geochemicals (significantly more Ca, Mg and K in the Organic soils) is tentatively explained on the basis of deterioration of soil structural characteristics in the Stockless system, leading to interruption of the supply of geochemicals by capillary water.

The data collected allowed crude geochemical budgets for the farm systems to be attempted and the work was, therefore, supplemented by the lysimeter studies.

The indications for this work are that the geochemicals in the Organic soil are more readily 'available' to leaching than those of the Stockless soil.

Phytometry, using both the old "Rika' barley variety

used in the long-term experiment, and the new varieties 'Julia' and 'Sultan', did not, in the main, back up the above findings. This was especially true of the field experiments when environmental factors other than geochemical supply, probably govern the performance of the barley.

However, in the majority of cases where significant differences were shown, the Organic system always shows better performance of the plant or greater flux of geochemicals into the plants than the Stockless system.

No indication of a developed dependance of the barley on the three farm systems was obtained. Nitrogen fixation by soil microorganisms appear to be unimportant on the Haughley systems.

SECTION 1. INTRODUCTION

PART I. THE PROBLEM

"The importance of inorganic fertilizers, especially those containing nitrogen, phosphorus and potassium (N.P.K.) to the continued fertility of intensive arable farm systems, has long been realised" (Boyd, 1961).

From this realisation the use of chemical fertilizers as the whole basis of modern agricultural systems, slowly developed. Today, not only are whole crop systems based on the continued and massive use of farm chemicals, but the stock in trade of the farm systems are crop varieties which have been produced by intensive breeding programmes to be productive only under these systems of high mineral input. Perhaps the best examples are the so-called "super cereals", all of which have high fertilizer requirements.

The literature on the importance of fertilizers for the maintenance of intensive crop systems is legion, and the evidence, has accrued from all parts of the world from the tropics to cold sub-arctic climates.

The United Nations Food Agricultural Organization prepared their definitive report on world agriculture in 1969, in which they concluded that the increases in world agricultural output required over the next decade, could only be met by an increase in the use of chemical fertilizers, especially nitrates.

The increases in the world use of fertilizers in recent yearshas been staggering. The comparable figures are:-

	N	P_2O_5	N.P.K.	
1954	5.5	6.6	17.4	Metric tons
1969	26.7	17.7	27.2	"

Future estimates indicate that the world consumption of nitrogen will approach 90 million tons by 1975 and 180 million tons by 1980 (Nelson, 1972).

In recent years, in fact, since the publication of Rachael Carson's (1963) classic work "Silent Spring", international concern has been awakened concerning pollution and contamination of the environment by the full cross-section of man's activities.

The first important steps to regulate pollution were taken against the continued use of agrochemicals, such as the pesticides (Aldrin and Dieldrin). The Dieldrin story was a case of pollution in that massive disruption of natural systems were brought about by the use of unnatural, i.e. man-created, chemicals.

Perhaps a more insidious form of disruption of our natural environment is caused by eutrophication. Eutrophication may be loosely defined as enrichment of the environment by the addition of natural biogeochemicals; these may be manufactured by man but are, in the main, natural products being derived from the Earth's crust. High on the list of eutrophicants are N.P.K. fertilizers.

Furthermore, although steps can be, and are being taken to alleviate the problems of eutrophication caused by sewerage and other piped wastes, it is not so easy to deal with agricultural chemicals that are uncontained, in that they are applied over very large areas of land and are allowed to drain away via the soil.

The proposed solution to the immediate problems of world food production are thus fraught with the problems of eutrophication. The main problems of eutrophication that have stirred up both the ecologists and the public concern (Commoner, 1968), are those relating to our "dying" lakes and rivers, where disturbance has caused the demise of the fish stocks. However, the most serious and least publicized aspects of eutrophication reported to date, relate to those areas of the world where illness and death of both cattle and human infants have been attributed to methaemoglobinaemia induced by excess nitrate in the diet.

The source of the nitrate has been mainly attributed to well water from areas in which massive amounts of chemical fertilizer are used (Gibson, 1943; Medovy et al., 1948; Stafford, 1947; Ellis B. S., 1951). The nitrate taken into the gut, being changed into nitrite by bacterial action, is then taken up through the gut wall, where it reacts with haemoglobin rendering it functionless for oxygen transport.

Bosch *et al*. (1950) presented the following important evidence from the intensive-farming areas of Minnesota:-

(1) Since 1947, one hundred and thirty nine cases of methaemoglobinaemia, including fourteen deaths of cattle or human infants were reported, all attributed to nitrate nitrogen in farm well water.

(2) That the well water implicated contained nitrate nitrogen in excess of 20 ppm.

(3) Recovery of patients suffering from cyanoses due to methaemoglobinaemia was obtained when uncontaminated water was substituted for the normal supply.

Similar occurrences have been reported from Canada, Belgium and the United States (Campbell, 1952). In Britain, Ewing and Mayon. (1951) reported the first case. In Ireland, Campbell *et al*. (1952) reported the first case, stating that cases are probably more widespread in rural areas than reports would suggest. There is thus little doubt that the continued and increased use of nitrates as fertilizers should be a source of grave concern.

Eutrophication of Crop Plants

The importance of nitrogen as a component of all living matter goes without saying, and analyses of organisms and parts of organisms for nitrogen are too numerous to attempt a review. Reports of the accumulation of nitrate in plant tissues are however, of interest in relation to the problem of eutrophication. Mayo (1895) and Ackerson (1963) found abundant crystals of potassium nitrate in the stocks and leaf axils of *Zea mays* L. Thorne (1957) has shown that the mid-rib of the leaves of the field turnip can contain in excess of 110,000 ppm (4% by weight) of nitrate nitrogen. Bury (1966) has shown that for a wide range of crops, the accumulation of nitrate nitrogen in the plants is correlated with the level of fertilizer application.

There is little doubt that food plants enriched in this way could be a significant source of nitrate in cases of methaemoglobinaemia, although search of the literature has recorded no instance where the cause has been attributed to nitrate in the food. It would, however, be foolish to overlook the possibility.

Organic versus Inorganic Farming

Ever since the Sandborn experiments were initiated in 1888 in America, arguments at both the scientific and the lay levels have been rife concerning the merits of inorganic, i.e. using chemical fertilizers, against organic, i.e. using only natural fertilizers, farming systems.

The Sandborn experiments showed in essence that the soil could be used almost as an inert medium on which crops could be grown year after year, so long as sufficient fertilizers were used. However, at the same time the experiments made it very clear that the soil itself was changed, the most significant feature being a reduction in the amount of nitrate nitrogen in the soil and a loss of soil structure.

The arguments of the advocates of organic farming have thus been developed along the lines that adequate application of nutrients may be obtained using natural organic fertilizers, such as farmyard manures, human sewage and mulched crop residues without derogatory effects on the soil.

Long-term success with organic farming has been reported from climatic regions of the world, as diverse as Northern Europe (Fred, 1961) and India (Singh, and Roysharma, 1958). The natural sources of organic manures are enormous. Cooke (1970) has shown that in the year 1956, forty seven million tons of organic manure was produced in the U.K. alone, that is just under two tons/acre of all crops and grass. This vast amount of manure contained about 40,000 tons of nitrogen, 170,000 tons of potassium and 40,000 tons of phosphorus.

The Soil Research Association have at their experimental farms at Haughley in Suffolk, maintained a long-term study comparing certain aspects of organic and inorganic farming, mainly relating to the health aspects of human nutrition.

A fruitful sphere of investigation was thus indicated to make a comparison of the biogeochemistry of a crop system under the contrasting farm systems of management at Haughley, paying special attention to the problems of eutrophication.

History of Haughley

Haughley research farms were founded in 1932, in the form of two small farms. These then became available for research purposes in 1939. The farm is situated at an altitude of over two hundred feet, and lies on Kimmeridgian chalky boulder clay (this is a drift deposit of heterogenous composition that contains sand, gravel and brick earth inter-bedded in the clay), with the exception of the south-east corner, where the land falls to stream.

The farm was divided into three sections for the purposes of comparing, "from the health point of view the three systems of farming, based on different conceptions of the nature of nutrition" (Allison, 1973).

Organic Section (O). No fertilizers or sprays are used. It depends for its fertility upon farm-yard manures (F.Y.M.), rough-composted with green weeds, and ley mixtures including deep-rooting weeds, thus representing a natural farm system based on recycling, not on added nutrients.

Mixed Section (M). This section was farmed in the conventional way, with farm-yard manures (F.Y.M.), conventional leys and chemical fertilizers and sprays applied according to local practice.

Stockless Section (S). This section was farmed without live-stock, but with liberal application of fertilizers and all organic matter derived from straw, stubble etc., ploughed back.

The outline of the farm is shown in Fig. 1. Throughout the experiments crop varieties derived from an originally pure genotype have been grown under the three different systems; the three types of farm have been kept quite separate with respect to the crops grown on them and the treatments which they received (see Plate 1).

OVERALL AIM OF THE WORK

To use one of the crops grown in the normal rotation at Haughley as a phytometer sensu Patterson (1960) to assess the differences which exist between the three farm systems.

The crop selected was BARLEY var RIKA.

As the barley has been grown for the 32 years of the Haughley experiment virtually as three "clones" (in that each system was planted only with seeds derived from that system), an integral part of the study related to differences, if any, between the three "clones" that had developed over the period of the main experiment.

Owing to the fact that the work described in this thesis was only an adjunct to the long term Haughley experiment, it was impossible to use a single new variety as a phytometer on a large scale without affecting the long term work. However during the course of this study the main Haughley experiment was terminated and the farm was put on a more commerical basis using newer improved crop varieties. The work was thus modified to include the new variety, SULTAN.

Owing to the fact that the bulk of the comparative work at Haughley to date related to crop yield sensu the agriculturalist and there was thus little or no information regarding the geochemistry of the farm systems, it was decided that a broad approach was necessary rather than a more detailed study on one nutrient or geochemical.

The following research programme was thus fixed and tailored into the main on-going experiment and normal farm practice.

1. The core of the work was to be a comparison of the farm

systems using the Barley var RIKA as a phytometer. The method of study being growth analysis sensu Blackman (1919)

2. Using the growth analysis as a basis comparisons of the geochemicals of the crops would be attempted paying special attention to the main eutrophicants, nitrogen, phosphorus and potassium.

3. As a background to the above studies, regular analysis of the soil was carried out, thus allowing comparison of the status quo of the soil geochemistry. Unfortunately, no detailed soil analyses had been carried out at the start of the main Haughley experiment so before and after, 32 years comparison was impossible.

4. Early on it was decided that as at least some of the background data was to be collected overall crude balance sheets for the most important geochemicals should be drawn up for each system as part of the study.

SECTION 2. COMPARISON OF THE GEOCHEMISTRY OF THE SOILS OF THE THREE FARM SYSTEMS

1. THE STATUS QUO OF THE SOILS

Aim of the Work. The aim of the work described in this section was to study the levels and changes, if any, in the total and available geochemicals in the three farm systems throughout one complete growing season. The period selected for study was 1972 and the fields used are shown in Map Fig.1

Methods. Samples were taken at monthly intervals between May and September, from the ploughing depth 0-9 inches. After mixing, sub-samples were dried at two different temperatures, the sub-samples to be used for total geochemical analysis being dried at 80°C, the others for analysis of available nutrients were air-dried for ten days. The dried samples were sieved through a No. 8 (2 mm mesh) sieve, prior to analysis.

The following analyses were carried out over the 1972 season:-

Total organic matter (loss on ignition)
Total organic nitrogen (Kjeldahl method)
Total potassium (Atomic Absorption Spectrophotometry)
Total calcium (" " ")
Total magnesium (" " ")
Total sodium (" " ")
Total zinc (" " ")
Total copper (" " ")

Available phosphorus (sodium bicarbonate (Olsen, et al 1954))
Available potassium (flame photometry)

All totals have been estimated after wet digestion (for full details see Section V).

Results. The results of the analyses are presented in tables, summary tables and summary diagrams. and all main tables in the Appendix pages 241-263. Each analysis is briefly discussed below.

Organic matter

The results of analyses carried out by McSheehy and Joseph, (1973) are presented below for comparison:-

	Mean Values.	S.E.	N
Organic field	3.38%	0.08	78
Mixed "	3.34	0.03	77
Stockless "	2.81	0.05	39

Soil organic matter consists of both dead and live fractions, and is of importance both in relation to the structural properties of the soil and the availability of geochemicals (Allison, 1973).

In order to gain more data on this important factor, further soil samples were collected at each sampling date. Soil cores were removed down to a depth of 20 inches, each core was divided into two, 0-6 inches and 6-20 inches, and the sub-cores were analysed for organic matter by loss on

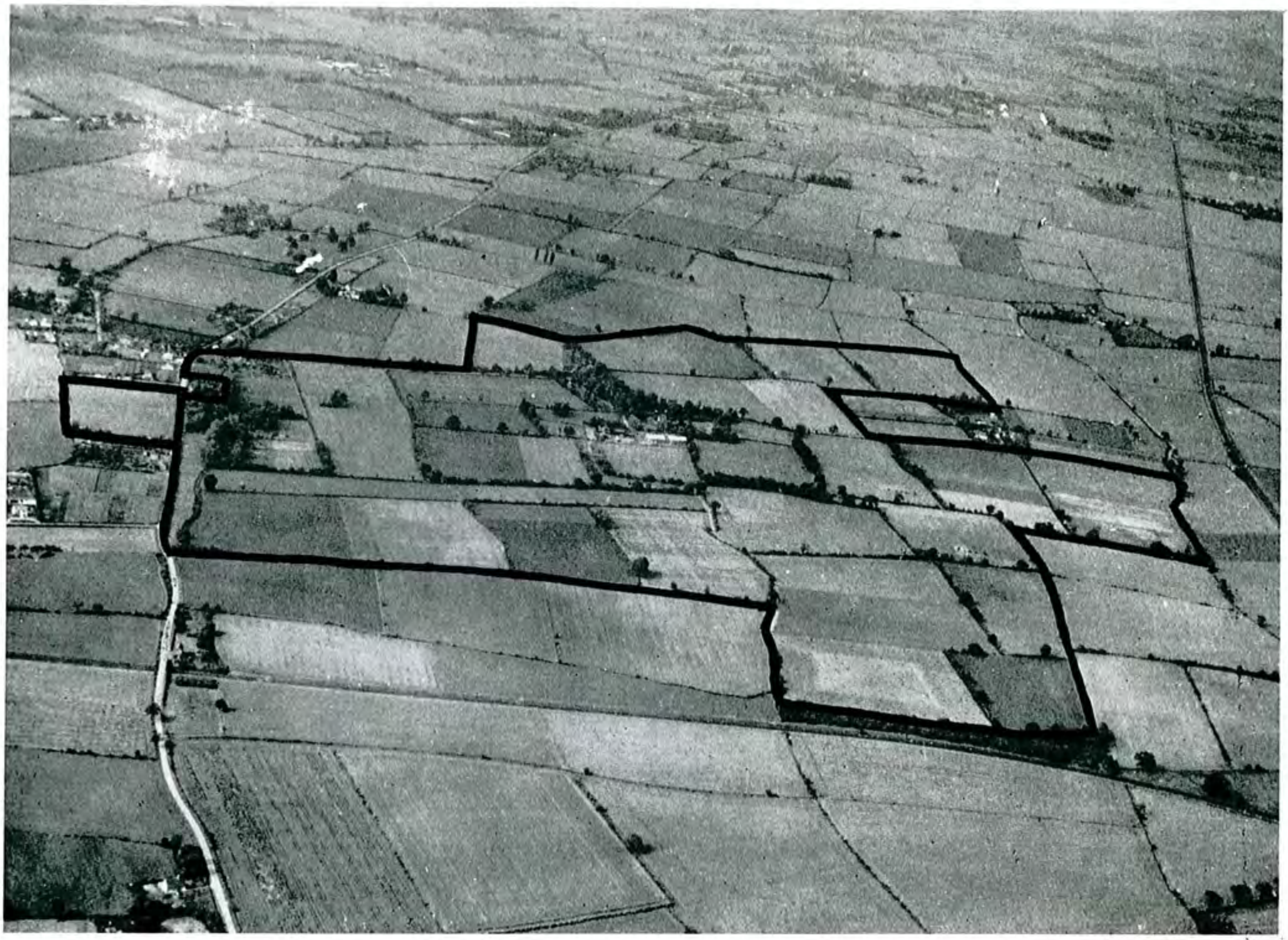
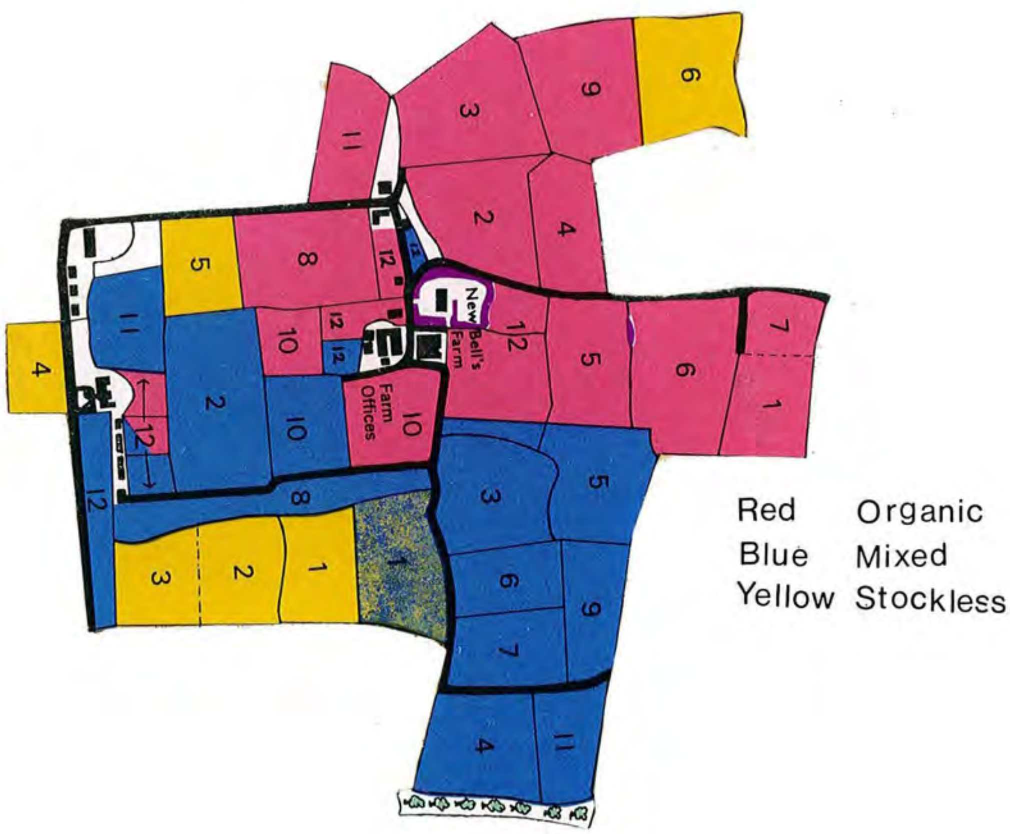


FIG. 1 Air photograph, showing Haughley Experimental Farm.



Out line Of The Fields.

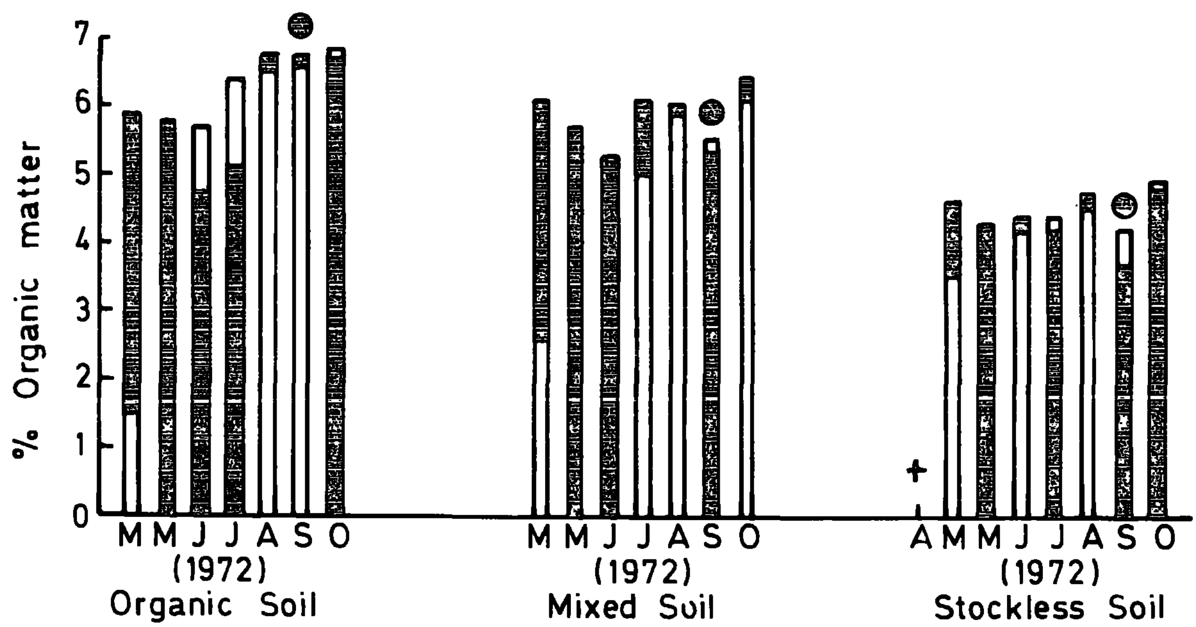


FIG. 2 Change in the Organic matter of the soils through the growing season 1972.

(0-6 inches depth, 6-20 inches depth.)

Harvest time + Fertilizer added

ignition. The results are shown in Table 1 and illustrated in Fig. 2.

Discussion. No explicable pattern of the distribution of the organic matter in the soil profile throughout the season, is evident. However, the results do indicate that the Stockless soils contain less organic matter than either the Mixed or the Organic soils, thus, bearing out the findings of McSheehy *et al*. (1973).

Total organic nitrogen

Most of the nitrogen of the soil is organically combined. Total organic nitrogen estimated in this work may contain small amounts of nitrogen fixed as ammonium (Bremner, 1965).

Results. The results of the analyses for total organic nitrogen are shown in Table 2 and illustrated in graphs (see Fig. 3).

A decrease was shown in organic nitrogen throughout the growing season 1972 in all three different systems. The levels in the Stockless field are significantly lower than those found in either the Organic or Mixed fields.

Summary Table

	Total Organic Nitrogen Mean ± S.E. (mg/g)
Organic	1.684 ± 0.078
Mixed	1.478 ± 0.098
Stockless	1.016 ± 0.1

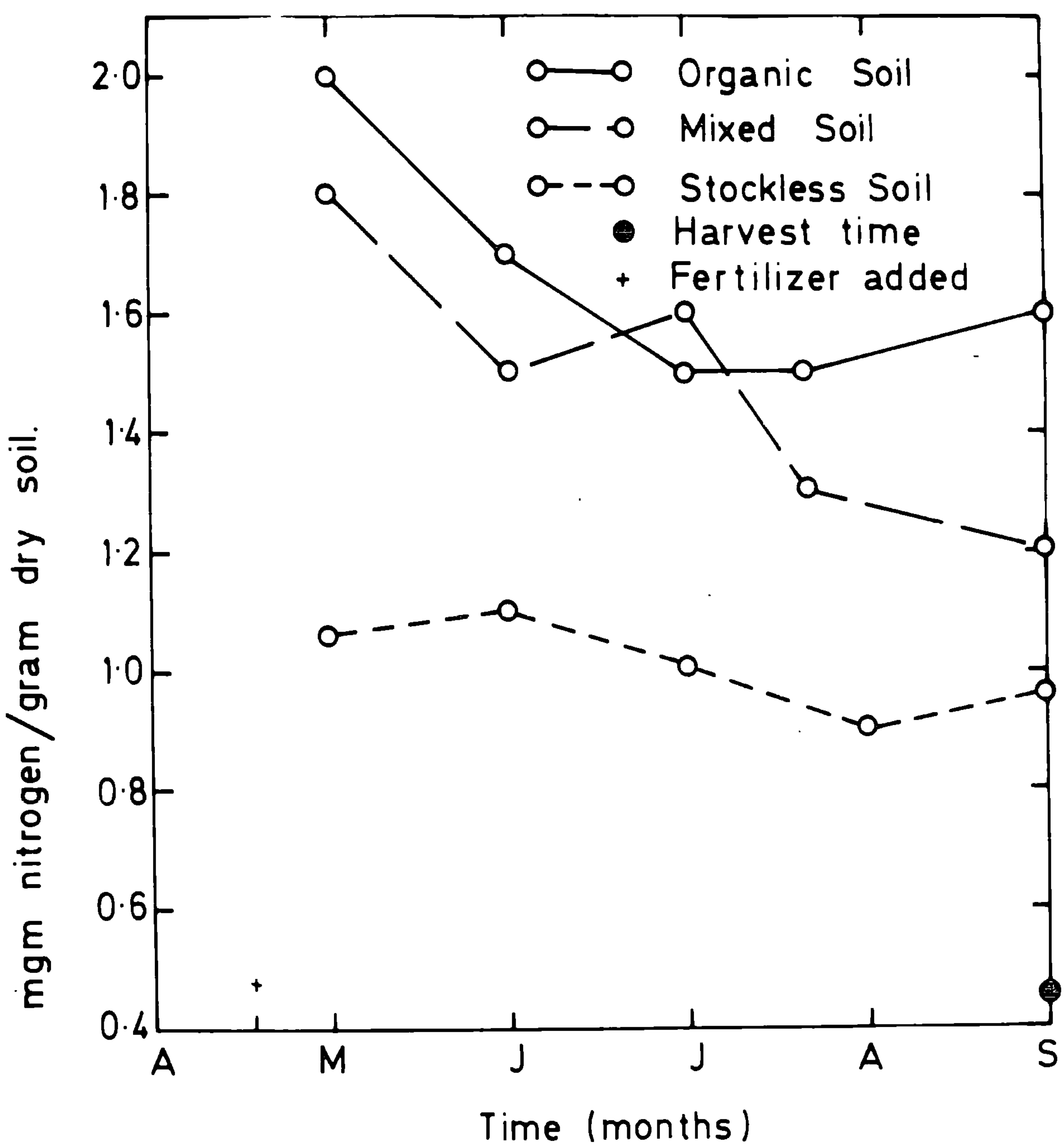


FIG.3 Change in total organic nitrogen in the soil through the growing season 1972.

The Exchangeable Geochemicals

Although exchangeability as measured by the soil chemist is a function of the extractant used, good correlations have been found between exchangeability, sensu the pedologist, and the fertility of the soil, sensu the agronomist (Russell, 1931).

Exchangeable phosphorus

The results of exchangeable phosphorus are shown in Fig. 4 and summarized in Table 3.

Interpretation. In 1972 both the Stockless and the Mixed fields showed an increase in available phosphorus, presumably due to the mobilization of phosphorus added in the fertilizers. In contrast, the Organic field showed a slight decrease over the first three months, followed by a marked increase up to harvest time. It is more difficult to explain the behaviour of the Organic field, except by the mobilization of phosphorus from the organic manures as a slower process.

The mean figures of the exchangeable phosphorus are summarized in the Summary Table below:-

	Mean ± S.E. (mg/g)
Organic	29.54 ± 7.62
Mixed	93.4 ± 5.23
Stockless	49.0 ± 8.1

The significance test showed that the mean levels of available phosphorus in the Mixed and Stockless fields are significantly

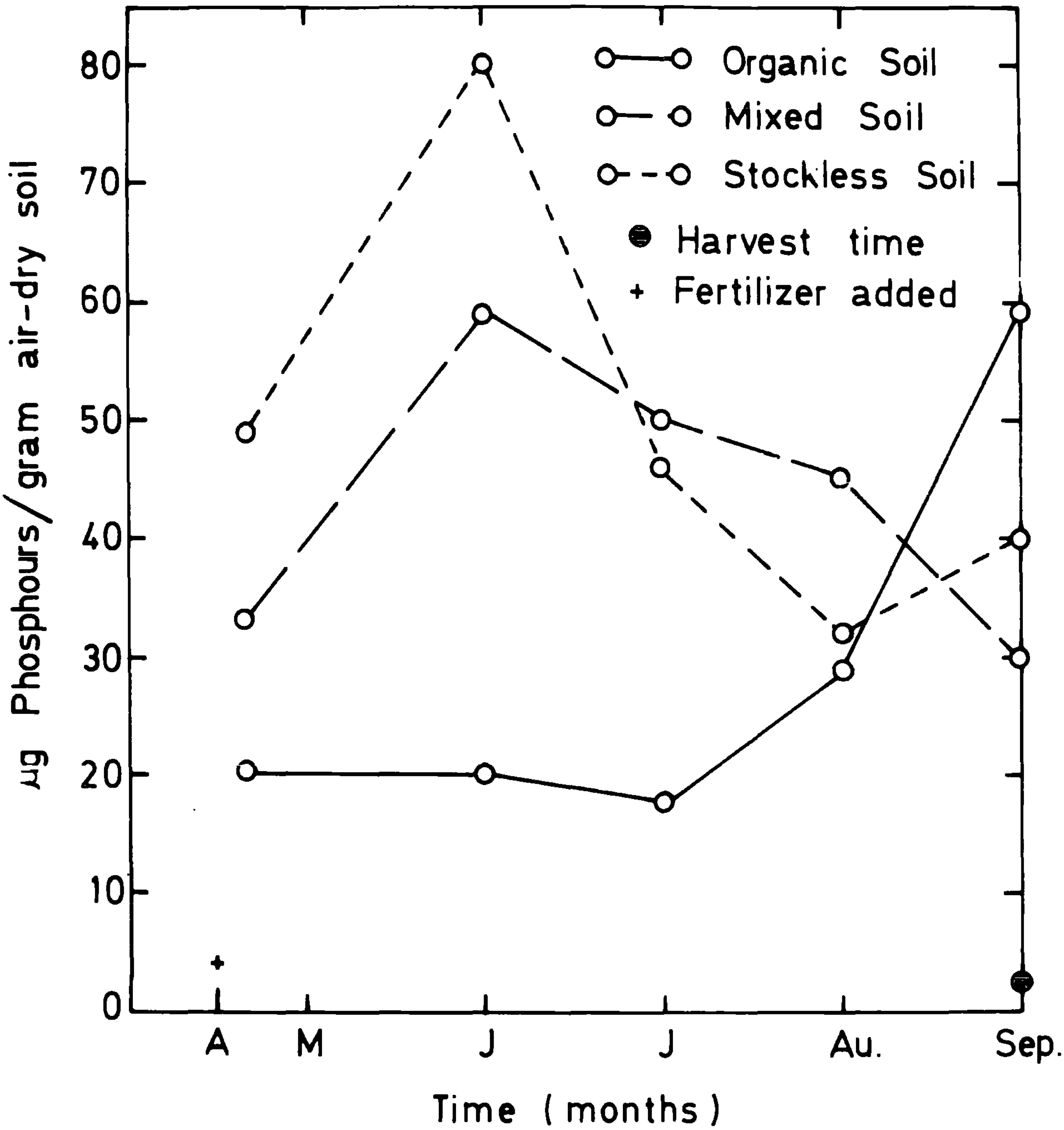


FIG.4 Change in available Phosphorus in the soils through the growing season 1972.

higher than those from the Organic field (see Table 3).

Available Potassium

The results of available potassium are shown in Table 4 and illustrated graphically in Fig. 5.

Interpretation. The pattern of changes of available potassium are similar for all soils over the growing season 1972. They all started high, presumably due to the addition of fertilizer and/or manures, and then fell away reaching a minimum at harvest time.

The mean figures of the available potassium are presented in the Summary Table below:

	Mean ± S.E. (µg/g)
Organic	409.9 ± 30.3
Mixed	258.7 ± 42.6
Stockless	289.12 ± 46.9

The Organic field is significantly richer in the available potassium than either the Mixed and Stockless fields. The test of significance is shown in Table 4.

Total potassium, calcium, magnesium, sodium, zinc and copper

The first four geochemicals were selected for study as they are normally present in soils in relatively larger amounts. Potassium is a specific nutrient, availability of which often limits plant growth, whereas calcium, magnesium and sodium, although specific components of plants,

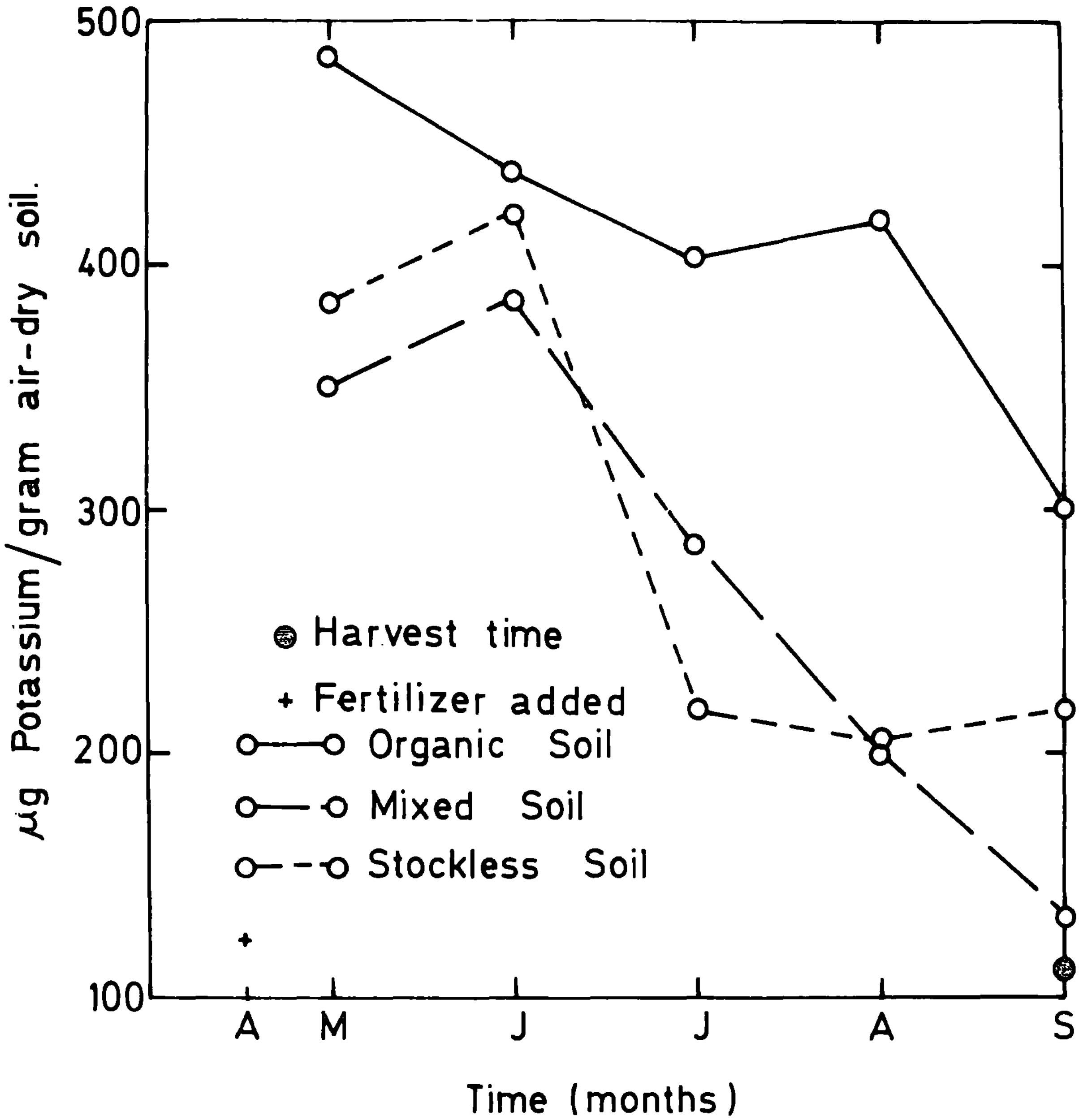


FIG. 5 Change in available Potassium in the soils through the growing season 1972.

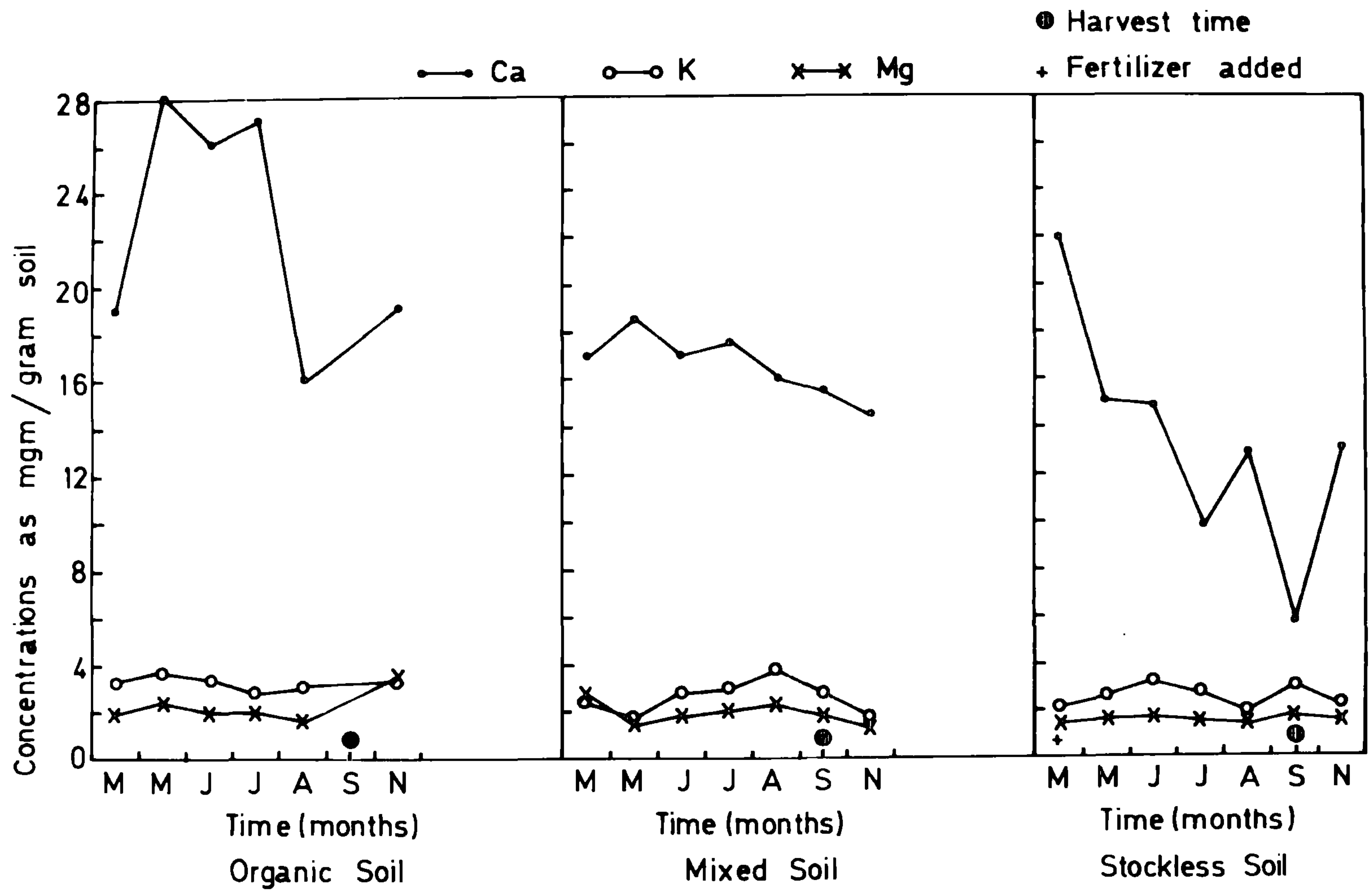


FIG.6 Concentration of Cations in soil from different fields through the growing season 1972.

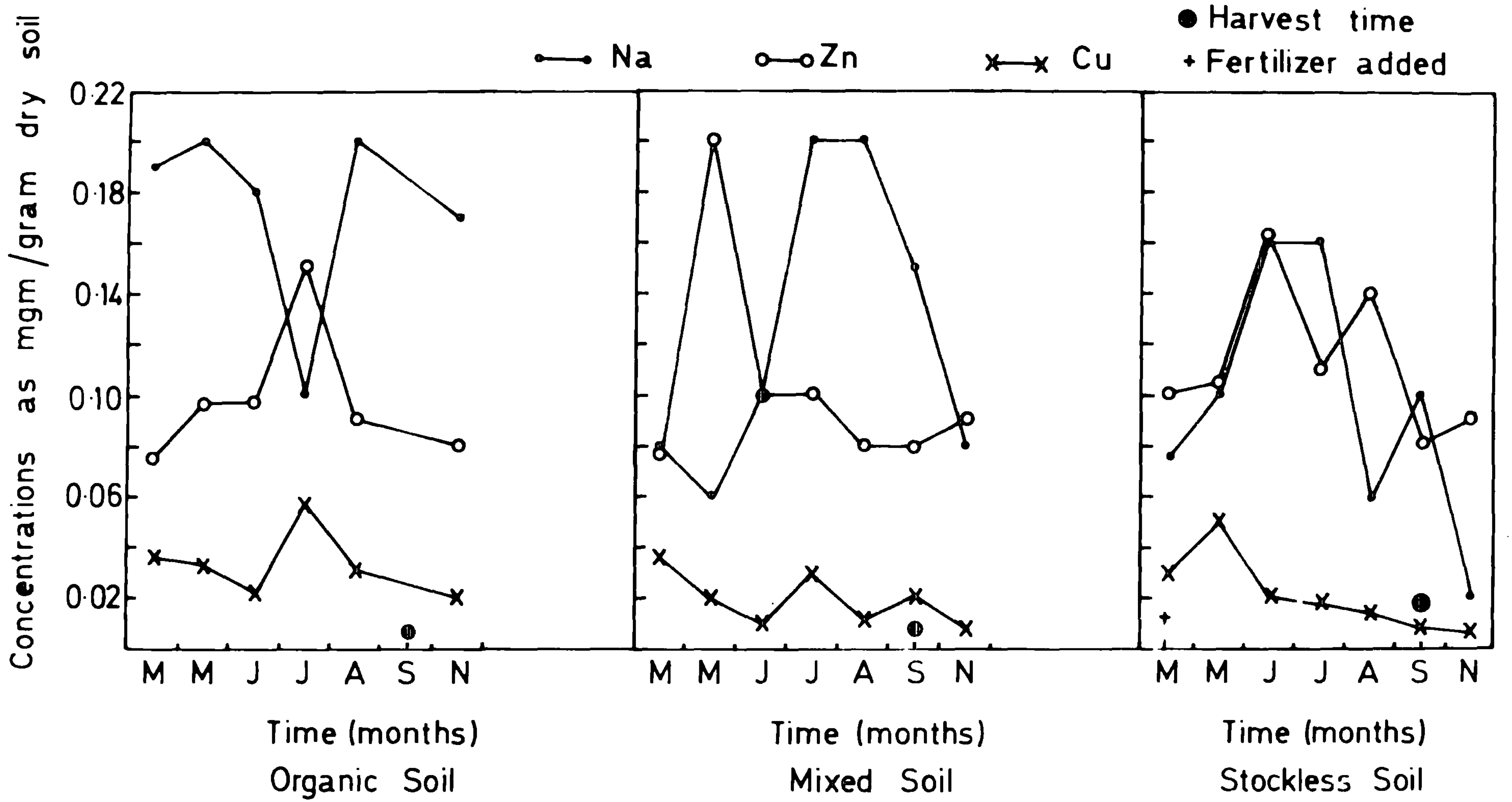


FIG.7 Concentration of Cations in soils from different fields through the growing season 1972.

are usually present in such excess in the soil that they are best regarded as 'background' geochemicals.

In contrast, zinc and copper, when present in large concentrations, are often regarded as toxic to plant growth.

The results of the analyses for all these geochemicals are illustrated graphically in Figs. 6 and 7. They are also summarized below and presented in detail in Table 5, found in the Appendix.

		Mean ± S.E. mg/g	
	Organic	Mixed	Stockless
Potassium (K)	3.2 ± 0.11	2.6 ± 0.03	2.5 ± 0.17
Calcium (Ca)	22.6 ± 2.16	16.8 ± 0.5	13.6 ± 1.7
Magnesium (Mg)	3.7 ± 0.3	1.8 ± 0.2	1.8 ± 0.07
Sodium (Na)	0.2 ± 0.01	0.3 ± 0.13	0.1 ± 0.02
Zinc (Zn)	0.02 ± 0.005	0.05 ± 0.03	0.05 ± 0.01
Copper (Cu)	0.08 ± 0.02	0.1 ± 0.02	0.1 ± 0.011

Discussion. The pattern of change of the total geochemicals throughout the growing season is of interest. Where the pattern of change appears to be synchronous, it is, without doubt, fortuitous. There is little reason to expect any measurable variation of total geochemicals throughout a growing season. The total geochemicals include:-

(1) The small exchangeable fraction that is readily available to plant growth, a fraction in which one might expect a pattern of change throughout the growing season.

(2) The much larger non-exchangeable fraction, which is

slowly released to replenish the exchangeable fraction by the weathering of the soil.

The comparison of the overall results however, are of interest and are discussed below.

Conclusions from the 1972 Analysis

The results of the 1972 analyses showed that there were significant differences between the following geochemicals:-

Calcium	O	>	M
	O	>	S
	M	>	S
Potassium	O	>	M
	O	>	S
Zinc	O	<	M

and indications of significant differences between the exchangeable geochemicals in the soil, shown below:-

Phosphorus	O	<	M
	O	<	S
Potassium	O	>	M
	O	>	S

It was, therefore, decided to expand the work on the exchangeable geochemicals over the 1973 growing season.

1973 GEOCHEMICAL INVESTIGATIONS

Sampling

Fifteen soil cores each to a depth of 9 inches were removed at two-monthly intervals from the three fields. Sub-samples were air-dried at 25-30^{o}C for ten days, and then ground to pass through a 30 mm mesh sieve prior to analysis for (1) available nitrate nitrogen; (2) available ammoniacal nitrogen; (3) nitrate; (4) nitrite nitrogen. Analyses were also carried out for, (5) exchangeable phosphorus; (6) exchangeable potassium.

These studies were followed by further analysis for total calcium, magnesium, potassium, sodium, phosphorus, zinc, lead, copper, aluminium and manganese, both at the beginning and the end of the growing season of 1973.

Exchangeable Phosphorus

The results are shown in Tables 6 to 9, and illustrated graphically in Fig. 8.

In all three fields the overall pattern of change was a reduction in the early part of the growing season as the phosphorus in the fertilizers and manures was mobilised and immediately used up; with a final increase to a high post-harvest figure correlated in all probability with the phosphorus remaining on the crop residues in an available form.

Significant differences were maintained throughout the growing season, the Organic field being the richest in exchangeable phosphorus, followed by the Mixed and then by the Stockless. A summary table, showing the means with their standard errors throughout the growing season 1973, is given below:

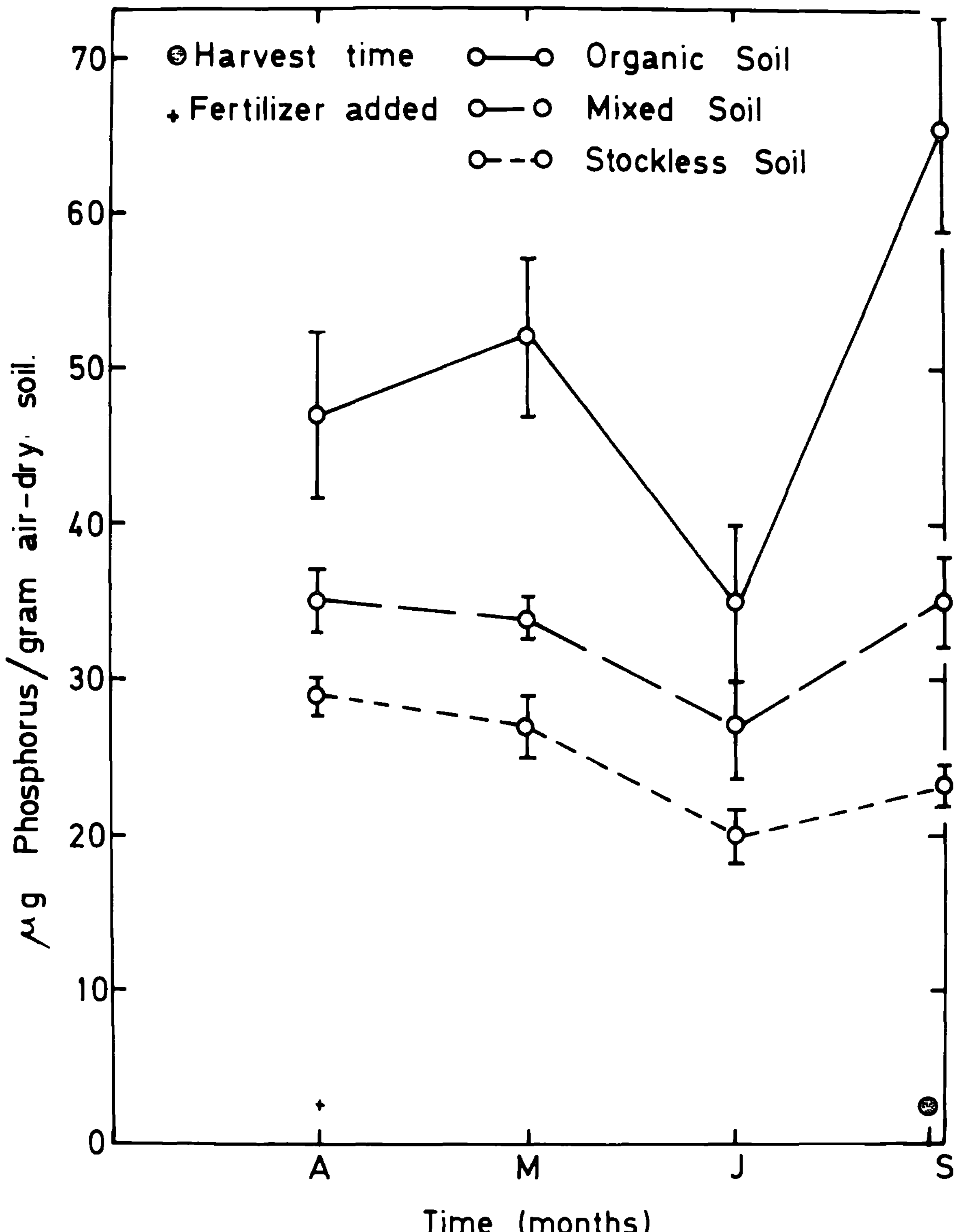


FIG.8

Change in available Phosphorus in soils through the growing season 1973.

TABLE 10

Statistical Analysis of Significance

Changes in the available Phosphorus in the soils

Date	Sample detail	d.f	F	P	R
14.4.1973	O-M	26	2.9655	2.06	*
	O-S	27	4.9825	2.05	*
	M-S	27	13.2511	2.05	*
21.5.1973	O-M	23	8.6284	2.07	*
	O-S	23	6.6194	2.07	*
	M-S	28	19.7938	2.05	*
24.7.1973	O-M	24	4.8764	2.06	*
	O-S	22	10.0162	2.07	*
	M-S	24	29.5570	2.06	*
4.9.1973	O-M	25	6.9693	2.06	*
	O-S	27	11.9811	2.05	*
	M-S	24	11.6652	2.06	*

O = Organic field; M = Mixed field; S = Stockless field

F = Variance ratio
P = Probability value
R = Result of significance
* = Significance difference at 5% level
N.S = No " " " " "
d.f = Degrees of freedom

	Mean ± S.E. μg/g		
	Organic	Mixed	Stockless
April	46.8 ± 7.0	35.3 ± 2.3	28.8 ± 1.3
May	52.2 ± 4.5	33.6 ± 1.4	27.2 ± 1.7
July	34.9 ± 4.2	26.9 ± 1.6	19.5 ± 0.9
September	56.6 ± 7.2	34.8 ± 3.4	23.5 ± 0.9

The results of the significance test are shown in Table 10.

Exchangeable Potassium

The results are shown in Tables 11 to 14, and are presented graphically in Fig. 9.

Interpretation. In all three fields there is a general decline in the amount of available potassium throughout the growing season, presumably due to uptake by crop.

Analysis of the means of available potassium shows that the Organic field is the richest in available potassium, and the Stockless field is the poorest. The mean values obtained with the standard errors are presented in the Summary Table below, and the results of the statistical analysis also shown in Table 15.

	Means ± S.E. μg/g		
	Organic	Mixed	Stockless
April	378.0 ± 24.9	276.6 ± 15.2	195.7 ± 8.4
May	316.0 ± 26.9	164.3 ± 8.1	129.9 ± 4.8
July	230.6 ± 7.5	152.3 ± 7.0	138.3 ± 7.2
September	172.3 ± 4.7	127.7 ± 10.7	115.4 ± 2.8

Studies of Available Nitrogen

The most important forms of available nitrogen in the soils are ammonia nitrogen (NH_3-N), nitrate nitrogen (NO_3-N), and

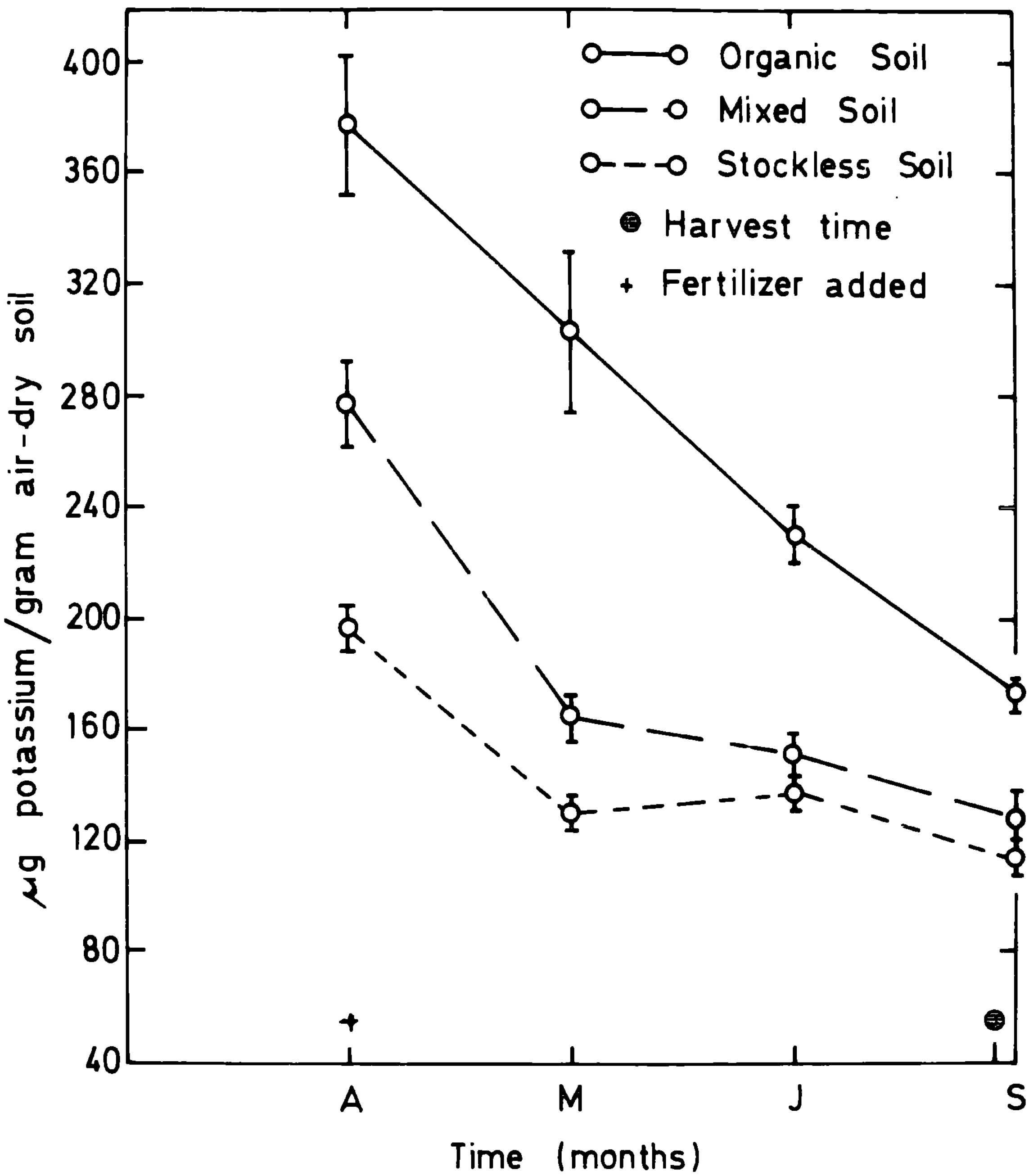


FIG. 9 Change in available potassium in the soils through the growing season 1973.

TABLE 15

Statistical Analysis of Significance

Changes in the available Potassium in the soils

Date	Sample detail	d.f	F	P	R
14.4.1973	O-M	27	2.7122	2.05	*
	O-S	27	3.7213	2.05	*
	M-S	28	4.0235	2.05	*
21.5.1973	O-M	28	2.8833	2.05	*
	O-S	28	3.7386	2.05	*
	M-S	28	5.8206	2.05	*
24.7.1973	O-M	23	8.8059	2.07	*
	O-S	23	10.164	2.07	*
	M-S	28	2.0825	2.05	N.S
4.9.1973	O-M	27	4.6225	2.05	*
	O-S	28	28.516	2.05	*
	M-S	27	1.4125	2.05	N.S

O = Organic field; M = Mixed field; S = Stockless field

F = Variance ratio
P = Probability value
R = Result of significance
* = Significance difference at 5% level
N.S = No " " " " "
d.f = Degrees of freedom.

nitrite nitrogen (NO_2-N). All these may be utilized by plants, but one form or the other may be preferentially absorbed, depending both on the species under investigation, its stage of development and the environmental conditions present during the period of uptake (Naftel, 1931; Thelin & Beaumont, 1934; Ghosh & Burris, 1950).

In general, it may be said that the availability of NH_3-N and NO_3-N in any soil is similar for most higher plants.

Ammonia-Nitrogen (NH_3-N)

It has been found that the amounts of ammonia present in the soil water are extremely small, and yet it is regarded as an important source of available nitrogen, especially in grasslands. It appears that the ammoniacal nitrogen is released by ammonia fixation in any soil which is permeated by plant roots. The excess of any not used by the micro-organisms is available for uptake by plant materials.

After fertilizer applications the ammonia may be present in the soil in excess. In these circumstances nitrification process may take place.

Results. The results of the analyses for ammonia-nitrogen expressed as milligrams/gram air-dried soil, are given in Tables 16 to 19, and shown graphically in Fig. 10.

Interpretation. There is no consistent pattern of changes in ammonia-nitrogen in all the different field systems.

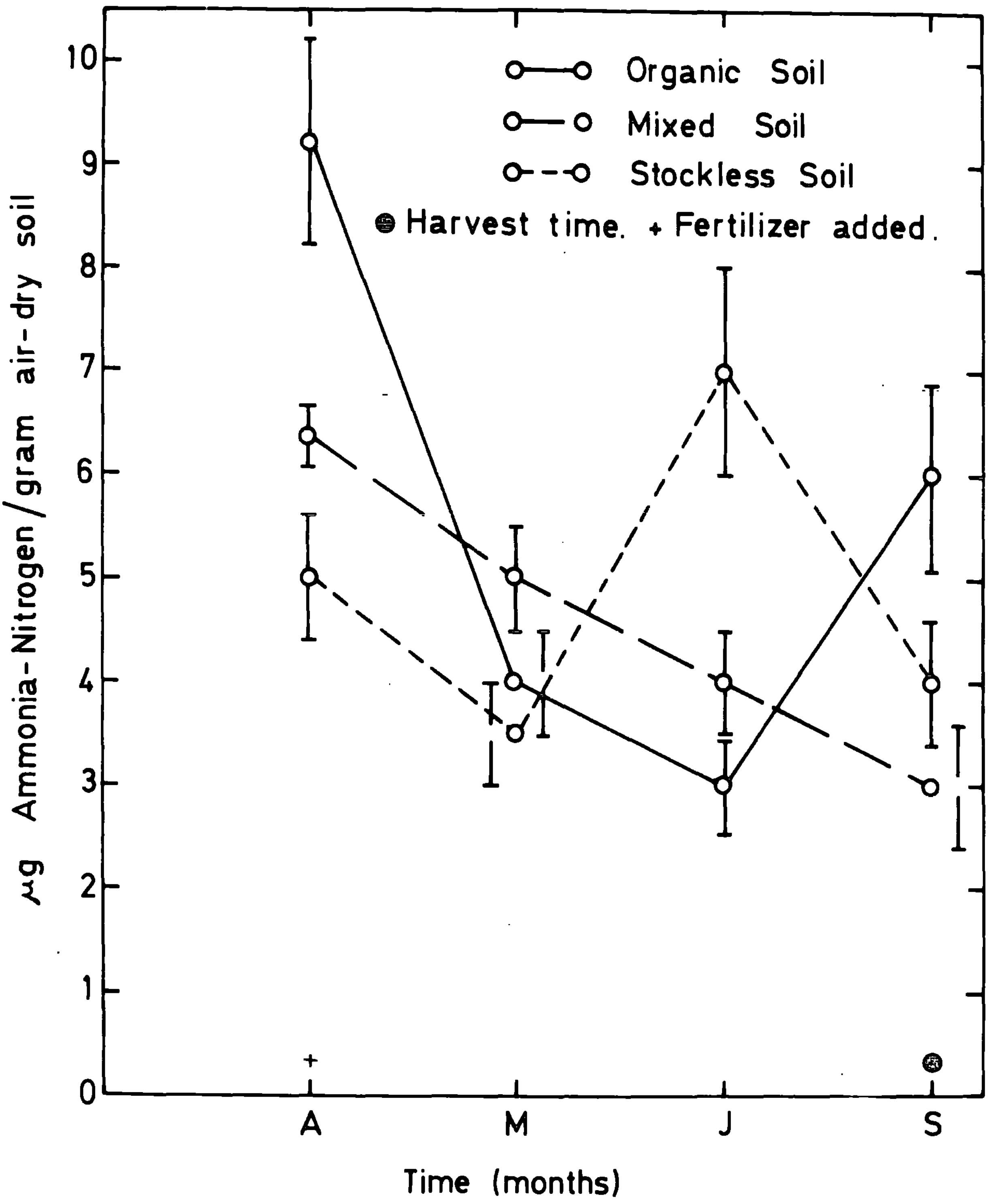


FIG. 10 Change in Ammonia-Nitrogen in soils through the growing season 1973.

TABLE 20

Statistical Analysis of Significance

Changes in the available Ammonia-Nitrogen in the soils

Date	Sample detail	d.f	F	P	R
14.4.1973	O-M	19	35.45	2.09	*
	O-S	23	9.057	2.07	*
	M-S	22	43.210	2.07	*
21.5.1973	O-M	23	21.600	2.07	*
	O-S	23	2.094	2.07	N.S
	M-S	28	15.6002	2.05	*
24.7.1973	O-M	24	30.462	2.06	*
	O-S	28	47.014	2.05	*
	M-S	22	32.112	.07	*
4.9.1973	O-M	28	32.051	2.05	*
	O-S	28	21.795	2.05	*
	M-S	28	16.660	2.05	*

O = Organic field; M = Mixed field; S = Stockless field

F = Variance ratio
P = Probability value
R = Result of significance
* = Significance difference at 5% level
N.S = No " " " " "
d.f = Degrees of freedom

Analysis of the mean data indicates that the Organic field has the highest concentrations of ammonia-nitrogen, while the Stockless field has the lowest, except that in July the Stockless field had the highest value then decreased by the next month.

See Summary Table below, and the results of the significance tests are shown in Table 20.

	Means ± S.E. µg/g		
	Organic	Mixed	Stockless
April	9.23 ± 0.9	6.3 ± 0.3	4.8 ± 0.6
May	3.9 ± 0.5	4.8 ± 0.5	3.5 ± 1.0
July	2.6 ± 0.5	3.8 ± 0.5	7.0 ± 1.0
September	5.6 ± 0.9	3.1 ± 0.6	3.9 ± 0.6

Nitrate Nitrogen (NO_3-N)

Nitrate nitrogen is probably the most important fraction of the available nitrogen of most soils, as it is present in most fertilizers and manures. Owing to the high solubility of all nitrates, it is subjected to massive losses due to leaching, yet, while present in the soil, water is readily available to plant growth.

Results. The results are summarized in Fig. 11, and also shown in Tables 21 to 24.

Interpretation. The levels of nitrate nitrogen fell throughout the growing season as the nitrate present in the manures and fertilizer was gradually lost by leaching and taken

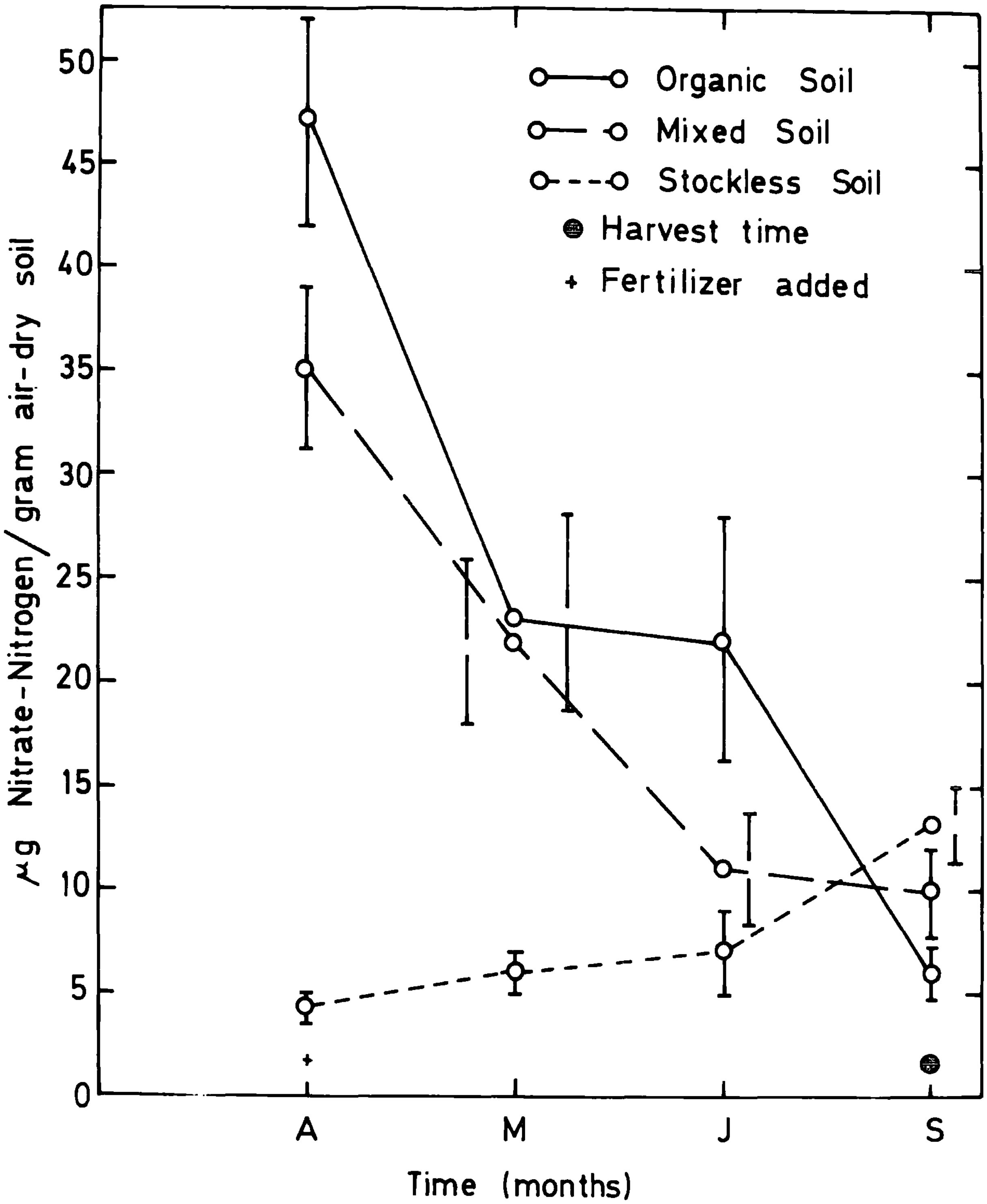


FIG. 11 Change in Nitrate-Nitrogen in the soils through the growing season (1973)

TABLE 25

Statistical Analysis of Significance

Changes in the available Nitrate-Nitrogen in the soils

Date	Sample detail	F	P	R
14.4.1973	O-M	5.937	2.09	*
	O-S	16.409	2.08	*
	M-S	17.1887	2.07	*
21.5.1973	O-M	0.5705	2.07	N.S
	O-S	6.032	2.07	*
	M-S	13.9778	2.05	*
24.7.1973	O-M	6.9190	2.05	*
	O-S	7.8350	2.05	*
	M-S	4.5619	2.05	*
4.9.1973	O-M	1.931	2.05	N.S
	O-S	22.250	2.05	*
	M-S	5.4316	2.05	*

O = Organic field; M = Mixed field; S = Stockless field

F = Variance Ratio
P = Probability value
R = Result of significance
* = Significance difference at 5% level
N.S = No " " " " "

up by the crop.

The gradual rise in the Stockless field points to more gradual mobilization of the nitrate from the fertilizers used. Analysis of the mean figures indicates that the Organic and Mixed fields are significantly richer in nitrate nitrogen than the Stockless field. This difference diminishes throughout the growing season.

Mean concentrations throughout the growing season in all different field systems are shown in the Summary Table below, and the significance results of the statistical analysis shown in Table 25.

	Means ± S.E. µg/g		
	Organic	Mixed	Stockless
April	46.9 ± 5.1	34.5 ± 4.4	3.6 ± 0.7
May	27.7 ± 5.2	21.6 ± 3.9	5.6 ± 1.4
July	22.0 ± 5.2	10.9 ± 3.4	6.7 ± 1.5
September	5.6 ± 0.9	12.7 ± 1.8	10.6 ± 1.6

Nitrite

As nitrite is usually present in the soils in very small quantities and is insignificant as a source of available nitrogen, only one set of analyses was carried out at the beginning of the growing season.

Results. The results are given in Table 26 .

Interpretation. The suspected low levels of nitrite were borne out, and no significant differences were recorded

TABLE 26

Soil Analysis

Available Nitrite-Nitrogen in three different field systems throughout the growing season 1973

Field Types / Sample no.	Organic	Mixed	Stockless
1	0.145	0.152	0.106
2	0.181	0.277	0.165
3	0.052	0.271	0.099
4	0.158	0.158	0.158
5	0.191	0.145	0.125
Mean ± S.E.	0.143 0.02	0.200 0.12	0.130 0.013
St. dev.	0.055	0.27	0.03

All concentrations as micrograms per one gram air-dry soil.

Soil collected in APRIL.

TEST OF SIGNIFICANCE

Field Type	t	p	R
O - M	0.72	2.31	N.S.
O - S	1.08	2.31	N.S.
M - S	1.54	2.31	N.S.

between the three field systems (see Table 26). Summary Table showing the means with their standard errors, is given below:-

	Means ± S.E. µg/g
Organic	0.143 ± 0.02
Mixed	0.200 ± 0.12
Stockless	0.130 ± 0.013

Comparison of a Range of Geochemicals in the Three Soils at the Beginning and End of the 1973 Growing Season

The results are summarized in Table 27.

Interpretation. The results for these analyses in the 1973 season are consistent with the original analyses. The others are simply useful background information for the interpretation of the results of mineral uptake in the main field experiments.

The significant differences found between all the three field systems throughout the growing season 1972/73, either in availability or in the totals, are shown in the Summary Table below. The results of significance tests are shown in Table 28.

Final Summary Table of the Significance Differences found between the Different Types of Field

Nutrient Details	Mean Value of the Year. Organic Field		Mixed Field		Stockless Field
1972.					
Organic matter 0-6 in.	5.80^{1}	≡	5.80^{3}	>	4.40
" " 6-20 in.	5.30^{3}	>	4.90^{1}	>	4.30

TOTAL GEOCHEMICALS

		Organic			Mixed			Stockless
	72 L.W.S.	22.6	>*	Cottage	16.80	>	Road	13.00*
Ca	73a Nappers	19.7	>*	"	17.40	>	Little	13.40*
	73b "	19.08	>	"	16.68	>	"	12.40
	72	2.30	>		1.80	>		1.70
Mg	73a	1.84	>		1.75	>	*	1.39
	73b	2.14	>		2.03	>		1.68
	72	3.2	>		2.6	>		2.5*
K	73a	2.6	>	*	2.5	>		2.0*
	73b	3.1	>		2.7	>		2.3
	72	0.2	<		0.3	>		0.1
Na	73a	0.1	≡	*	0.1	≡	*	0.1
	73b	0.2	>		0.1	<		0.2
	72	0.08	≡	*	0.11	<		0.12
Zn	73a	0.09	≡		0.10	≡	*	0.07*
	73b	0.08	≡		0.08	≡		0.07
	72	0.03	<		0.05	≡		0.10*
Cu	73a	0.05	<	*	0.14	>		0.04*
	73b	0.o2	≡		0.o2	≡		0.02

AVAILABLE GEOCHEMICALS (NUTRIENTS)

		O			M		S	
P	72	29.5^{1}	<	*	43.4^{4}	<	49.0^{4}⊚	*
	73	49.9^{4}	>	*	32.7^{4}	>*	24.8	*
K	72	409.9^{4}	>	*	258.7	<	289.1^{2}⊚	*
	73	274.2^{4}	>	*	180.2	>*	144.8	*
NH_3-N	73	5.3^{2}	>	*	4.5^{1}	<*	4.7^{10}	*
NO3-N	73	29.3^{3}	>		19.4^{3}	>	6.6^{1}	*
NO2-N	73	0.14	≡		0.20	≡	0.13	

5.8^{1} = Time of significance difference per season

⊚ = beside the mean values of the stockless field, indicate the number of times these values showed significant differences with those of the organic field.

* = significance difference at 5% level.

INTERPRETATION

TOTAL GEOCHEMICALS

It is of interest that although, as stated above, short term changes in the total geochemicals present in the soil profile can be rulled out, it became evident that there are certain differences borne out by statistical analysis between the three systems. This might at first sight be interpreted as fortuitous being caused by intra field variations. However similar differences were found in 1973 when in the case of the organic and stockless systems different fields were under investigation (1972 organic (lower Wassex South), Stockless (Road field) and in 1973 Organic (Nappers), Stockless (little)) See Map in figure 1.

Thus it would appear that the differences are real phenomena related to the 32 years of differing managements. It would then appear that the stockless field has significantly less total calcium, magnesium and potassium and significantly more Copper and Zinc than the organic field.

The latter could be explained by the addition of these heavy metals in the agricultural chemicals, the intermediate results from the mixed fields likewise due to the fact that they receive proportionately less agricultural chemicals.

The presence of the greater amounts of total calcium, magnesium and potassium on the organic field will be discussed later.

AVAILABLE GEOCHEMICALS (NUTRIENTS)

Apart from the result for phosphate in 1972, and nitrite nitrogen which was present at very low levels, all the available nutrients are significantly higher in the organic field compared with the stockless field system. The mixed fields are somewhat intermediate between the other two. No explanation can be advanced for the results of phosphate in 1972.

The overall higher levels of available K & P and especially of both nitrate and ammonia nitrogen are undoubtedly a reflection of the higher levels of organic matter present in the organic fields.

2. GEOCHEMICAL BALANCE SHEETS

Although it was realised that any short-term measurement of the cycle of the geochemicals in the farm systems would only be very approximate, it was decided that such a study could provide an important background for the rest of the work. To this end, simple experiments based on field lysimeters (*sensu* Helmut *et al*., 1940) were set up. For experimental details and full results, see Appendix.

The experiments are designed to allow estimations of the following to be made for each section:- (a) Additions to the systems; (2) Losses from the systems.

(A) Addition to the Systems

(1) Addition in the rainwater

Rainwater was collected throughout the growing season in standard rain gauges modified to avoid contamination of the samples. The results of the analyses are shown in Table 29 and, although high, are consistent with those recorded in other lowland areas given over to farming.

Tables 30 and 31 show the figures for addition of the nutrients calculated both over the period of the study and extrapolated to cover a whole year.

In the knowledge that the main magnification of any source of inaccuracy would be the conversion of volume to area, results are computed based both on the areas of the shallow and deep lysimeters, the mean values being used in the overall balance

TABLE 29

Chemical Analysis

Analysis of rain water collected from
April 1972 to December 1972

Date	NO_3-N	Organic N	Total N	K	Ca	Mg	Na
11/4-1/5	0.84	1.50	2.34	3.00	7.00	2.50	2.40
2 /5-22/5	0.22	0.70	0.92	1.80	1.80	0.44	2.00
23/5-22/6	0.14	1.50	1.64	3.50	3.80	0.75	7.20
23/6-22/7	0.22	1.50	1.72	0.50	3.00	0.31	0.80
26/7-19/8	0.00	0.00	0.00	0.30	1.10	0.25	0.90
20/8-19/9	0.90	0.50	1.40	1.10	8.30	7.30	0.60
20/9-10/12	0.84	5.10	2.94	4.00	7.00	9.00	0.60
Mean ± S.E	0.53 ± 0.15	1.80 ± 0.70	2.33 ± 0.75	2.00 ± 0.60	4.60 ± 1.10	2.90 ± 1.40	3.10 ± 1.00

All concentrations as μg/ml

S.E = Standard error

TABLE 30

Chemical Analysis

Total nutrients in rain water added to the systems

Amounts of Ions added to Shallow Lysimeters

Date 1973	Rainfall Inc.	Rainfall Cn.	Volume L.	Nutrient details mg/volume/month						
				NO_3-N	Organic N	Total N	K	Ca	Mg	Na
1/1- 1/2	1.59	3.98	57.31	-	-	-	-	-	-	-
3/2- 5/3	1.13	2.83	55.15	-	-	-	-	-	-	-
6/3- 9/4	1.30	3.25	46.80	-	-	-	-	-	-	-
11/4- 1/5	0.57	1.43	20.6	17.0	31.0	48.0	62.0	144.0	52.0	87.0
/5-22/5	0.99	2.50	36.0	8.0	27.0	35.0	63.0	65.0	16.0	72.0
23/5-22/6	1.86	4.60	66.5	9.0	98.0	107.0	233.0	253.0	50.0	480.0
23/6-25/7	2.22	5.55	79.9	18.0	118.0	136.0	40.0	240.0	25.0	64.0
26/7-19/8	0.80	2.00	28.8	-	-	-	9.0	32.0	7.0	26.0
20/8-19/9	1.61	4.03	58.0	51.0	31.0	82.0	64.0	481.0	423.0	35.0
22/9-10/12	3.66	9.15	131.8	110.0	198.0	198.0	527.0	923.0	1186.0	791.0
TOTAL.	15.77 inc./year	39.34 Cn/year	580.9 L/year	213.0	503.0	706.0	998.0	2138.0	1759.0	1555.0

- = No samples were collected.

Amounts of Nutrients to be added in:-

	NO_3-N	Organic N	Total N	K	Ca	Mg	Na
lb/acre/year	1.92	6.5	7.93	7.10	16.56	10.43	11.16
Kg/ha/year	0.87	2.94	3.81	3.26	7.51	4.73	5.06

Area of lysimeter = 1.2 m x 1.2 m x 0.25 m depth

$$= 1.44 \text{ sq. m} = \frac{1.44}{4046.86} = 0.0003558 \text{ hectares}$$

$$= 0.0003558 \times 2.205 \text{ acres}$$

$$\text{Amounts added} = \frac{\text{Concentration in Kg}}{\text{area ha}} = \text{Kg/ha}$$

TABLE 31

Chemical Analysis

Total nutrients in rain water added to the systems

Amounts of Ions added to Deep Lysimeters

Date 1972	Rainfall Inc.	Rainfall Cn.	Volume L.	Nutrient details mg/volume/month						
				NO_3-N	Organic N	Total N	K	Ca	Mg	Na
1/1- 1/2	1.59	3.98	4.3	-	-	-	-	-	-	-
3/2- 5/3	1.13	2.83	3.1	-	-	-	-	-	-	-
6/3- 9/4	1.30	3.25	3.51	-	-	-	-	-	-	-
11/4- 1/5	0.57	1.43	1.54	1.0	2.0	3.0	5.0	11.0	4.0	7.0
2/5-22/5	0.99	2.50	2.70	1.0	2.0	3.0	5.0	5.0	1.0	5.0
23/5-22/6	1.86	4.60	5.99	1.0	7.0	8.0	18.0	19.0	4.0	36.0
23/6-25/7	2.22	5.55	5.94	1.0	9.0	10.0	3.0	18.0	2.0	5.0
26/7-19/8	0.80	2.00	2.16	-	-	-	1.0	2.0	1.0	2.0
20/8-19/9	1.61	4.03	4.36	4.0	2.0	6.0	5.0	36.0	32.0	3.0
22/9-10/12	3.60	9.15	9.88	8.0	15.0	23.0	40.0	69.0	90.0	59.0
TOTAL.	27.52 inc./year	39.34 Cn/year	42.52 L/year	16.0	37.0	53.0	77.0	160.0	134.0	117.0

- = No samples were collected.

Amounts of Nutrients to be added in:-

	NO_3-N	Organic N	Total N	K	Ca	Mg	Na
lb/acre/year	1.87	6.34	8.21	7.05	16.21	10.22	10.93
Kg/ha/year	0.85	2.88	3.73	3.19	7.35	4.64	4.95

Area of lysimeter = 0.37 m at top x 0.29 m at base x 0.25 m depth

$$= 0.108 \text{ sq. m} = \frac{0.108}{4046.86} = 0.0000266 \text{ hectares}$$

$$= 0.0000266 \times 2.205 \text{ acres}$$

Amounts added $= \frac{\text{Concentration in Kg}}{\text{area ha}} = \text{Kg/ha}$

sheets for
/ the farm systems.

(2) Inorganic and Organic Fertilizers

Replicate samples of all fertilizers were analysed for their component geochemicals, so that knowing the rate of applications values for the addition of the nutrients from that source could be calculated. These are presented in Table 32.

(3) Addition to the System by the Seeds

Analysis of the seeds for the various geochemicals allowed calculation of the amounts of nutrient added in this way. The results are shown in Table 33.

(4) Addition by Nitrogen Fixation

Introduction. Of all the important plant nutrients, only nitrogen is added by direct biological activity; that of fixation by procaryotic organisms living both free in the soil and in symbiotic union with certain higher plants (Stewart, 1968).

Methods. In recent years many workers (Stewart *et al*., 1967; Hardy *et al*., 1968; Rice and Paul, 1971; Waughman, 1971) have used the acetylene reduction technique to assess the nitrogen fixing potential of soils. The method used, which is described in Section V, is a modification of that used by Waughman (1971).

Results. The preliminary tests using soil with

TABLE 32

Chemical Analysis

(A) Chemical analysis of the Organic fertilizer (poultry)

	Nutrient details						
	NO_3-N	NO_3	N	K	Ca	Mg	Na
Mg/g	2.86	12.6	25.5	17.35	58.8	11.1	2.68
Amounts to be added to the two lysimeter types in Kg/ha	3.6	15.8	32.0	21.8	73.8	13.9	4.3

(B) Chemical analysis of the Inorganic fertilizer

	Normal Fertilizer					High fertilizer				
	N	K	Ca	Mg	Na	N	K	Ca	Mg	Na
Mg/g	25.5	96.9	4.4	1.4	1.5	25.5	96.9	4.4	1.4	1.5
Amounts to be added to the two lysimeter types in Kg/ha	19.2	72.9	3.3	1.1	1.1	19.2 +15.5 =34.7	72.9 37.5 110.4	3.3 - 3.3	1.1 - 1.1	1.1 - 1.1

TABLE 33

Chemical Analysis

Chemical Nutrients in Seeds as mg/g dry seeds.

Type of Seeds		Nutrient Details							
		NO_3-N	NO_3	N	K	P	Ca	Mg	Na
Organic	(O)	0.294	1.302	0.123	2.934	0.225	0.550	0.953	1.090
Mixed	(M)	0.063	0.117	0.122	2.934	0.358	0.540	0.950	0.094
Stockless	(S)	0.071	0.316	0.114	2.930	0.546	0.630	0.900	1.240

Amounts of ions added to the Systems.

Seed type	Rate	NO_3-N	NO_3	N	K	P	Ca	Mg	Na
O	lb/acre	0.003	0.012	0.001	0.026	0.002	0.005	0.009	0.01
	Kg/ha	0.0039	0.013	0.0012	0.026	0.0023	0.006	0.010	0.011
M	lb/acre	0.001	0.0011	0.0011	0.0261	0.003	0.005	0.009	0.008
	Kg/ha	0.0013	0.0012	0.00122	0.0293	0.0035	0.0054	0.0096	0.0094
S	lb/acre	0.00064	0.0028	0.001	0.0263	0.0049	0.006	0.0085	0.011
	Kg/ha	0.00072	0.00317	0.0014	0.0294	0.0055	0.0053	0.0096	0.024

no added sugar consistently gave no 'fixation'. Addition of 2.5 mls of 50% glucose to 30 grams soil and incubation at 12°C stimulated 'fixation', and time curves were plotted for ethylene production over periods of up to 140 hours.

Investigations were carried out on the three soil types in April, June, August and September 1973. The results are shown in Figs. 12 to 19, and in Table 34.

To calculate the amount of nitrogen fixed from the data obtained on ethylene production, the conversion figures (1 mole N_2 fixed for 3 moles C_2H_2 reduced) (Hardy et al., 1968; Rice et al., 1971) were used. Owing to the fact that considerable amounts of glucose had to be added in order to stimulate fixation, the results used in the overall balance sheet must be regarded with great caution. These are shown in the Summary Table below, and presented in detail in Table 35, all found in the Appendix pages 264-265

Organic	39.87	Kg N/ha/season
Mixed	25.98	"
Stockless	73.92	"

Nevertheless, it would appear fair to use the levels recorded to compare the nitrogen fixation potentials of the three soil types. Table 35 shows the results of the analysis of variance of the maximum levels of simulated fixation measured throughout the growing season. The overall picture is that

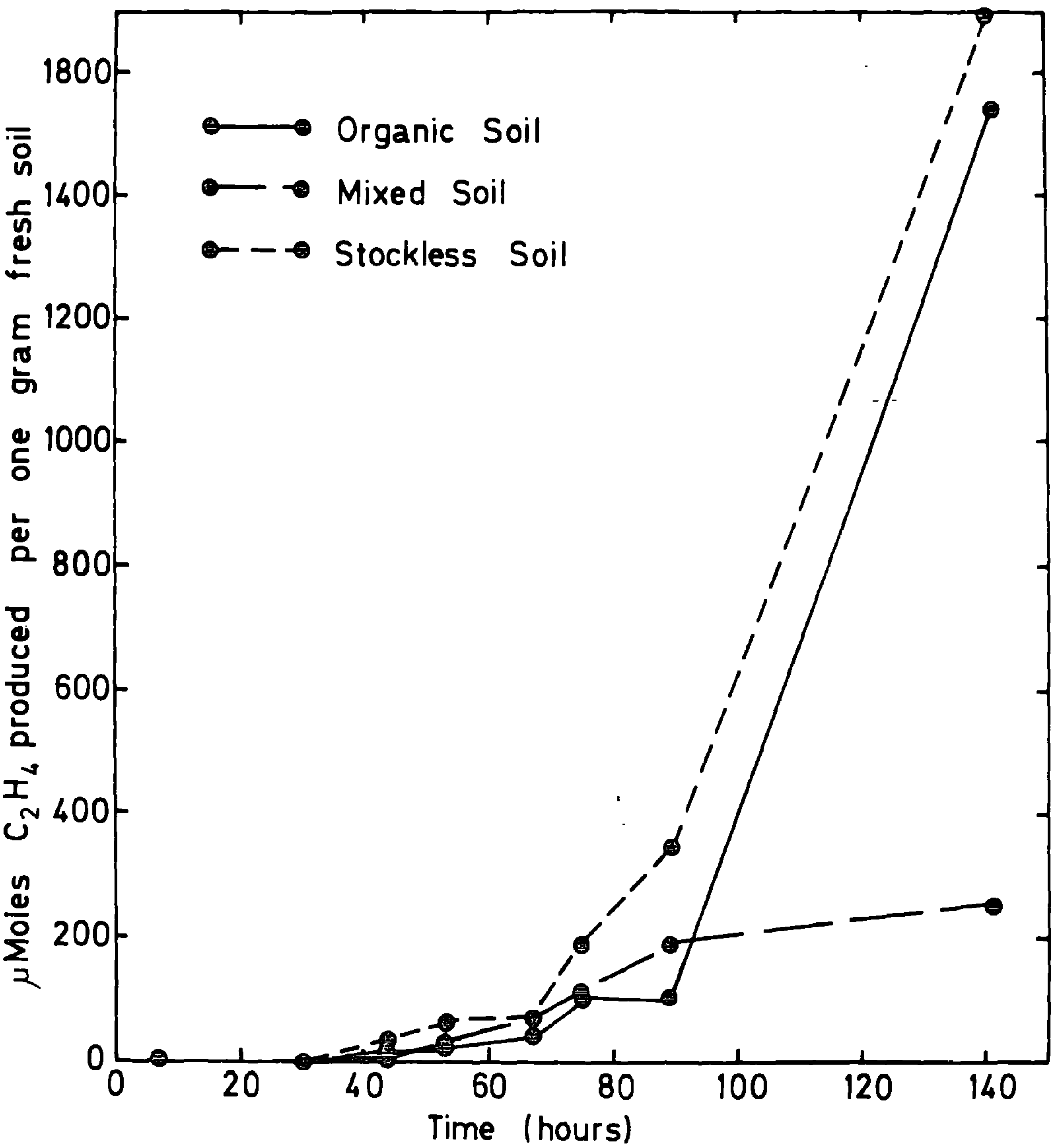


FIG.12 Time Course of Acetylene reduction by soil micro organisms in different types of soil. April 1973. Soil samples were incubated in an average 12°C with 2·5 ml. of 5% Glucose.

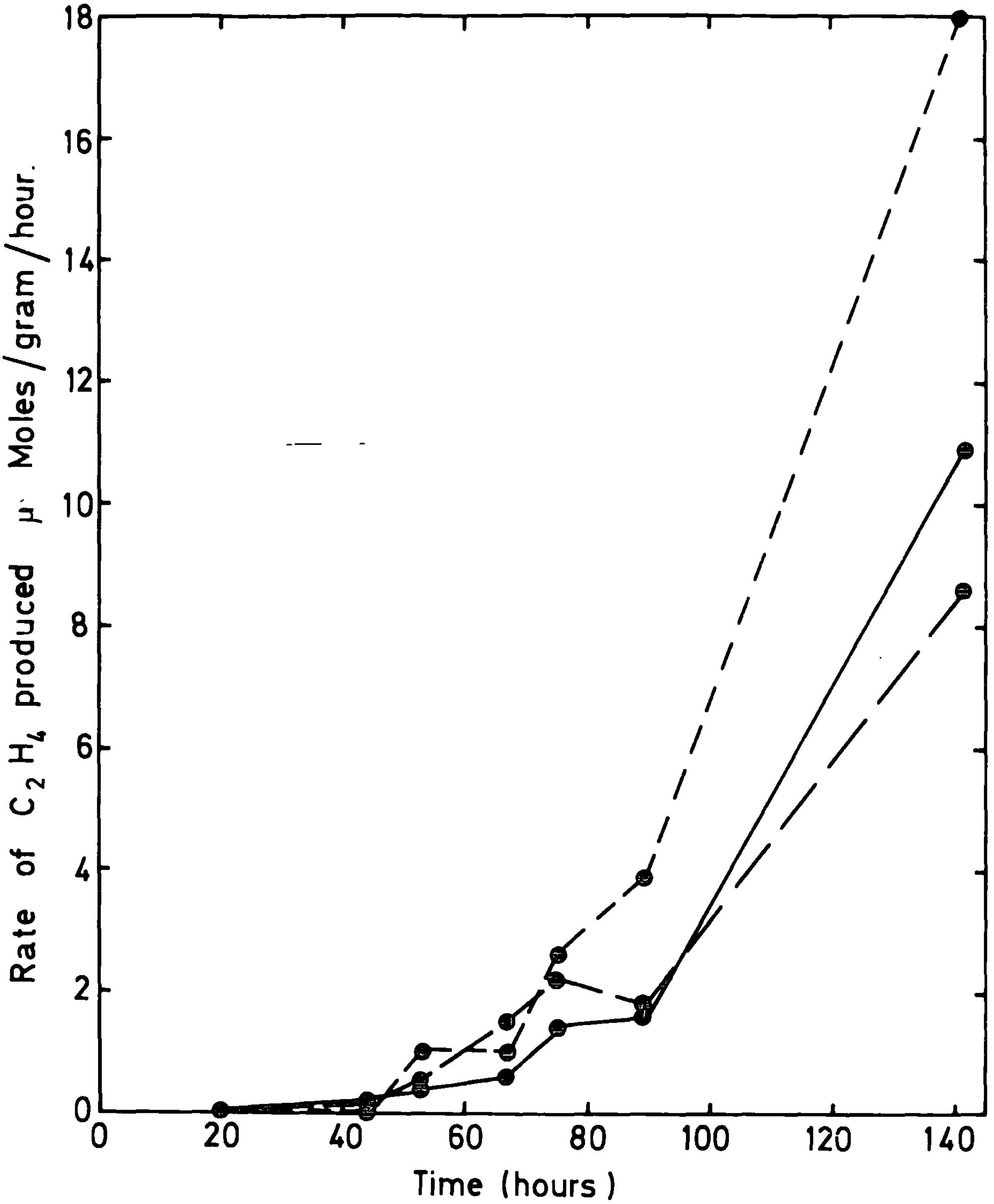


FIG.13 Time Course of Acetylene reduction by soil micro organisms in different types of soil; April 1973 soil samples were incubated in an average 12°C with 2·5 ml. of 5% Glucose.

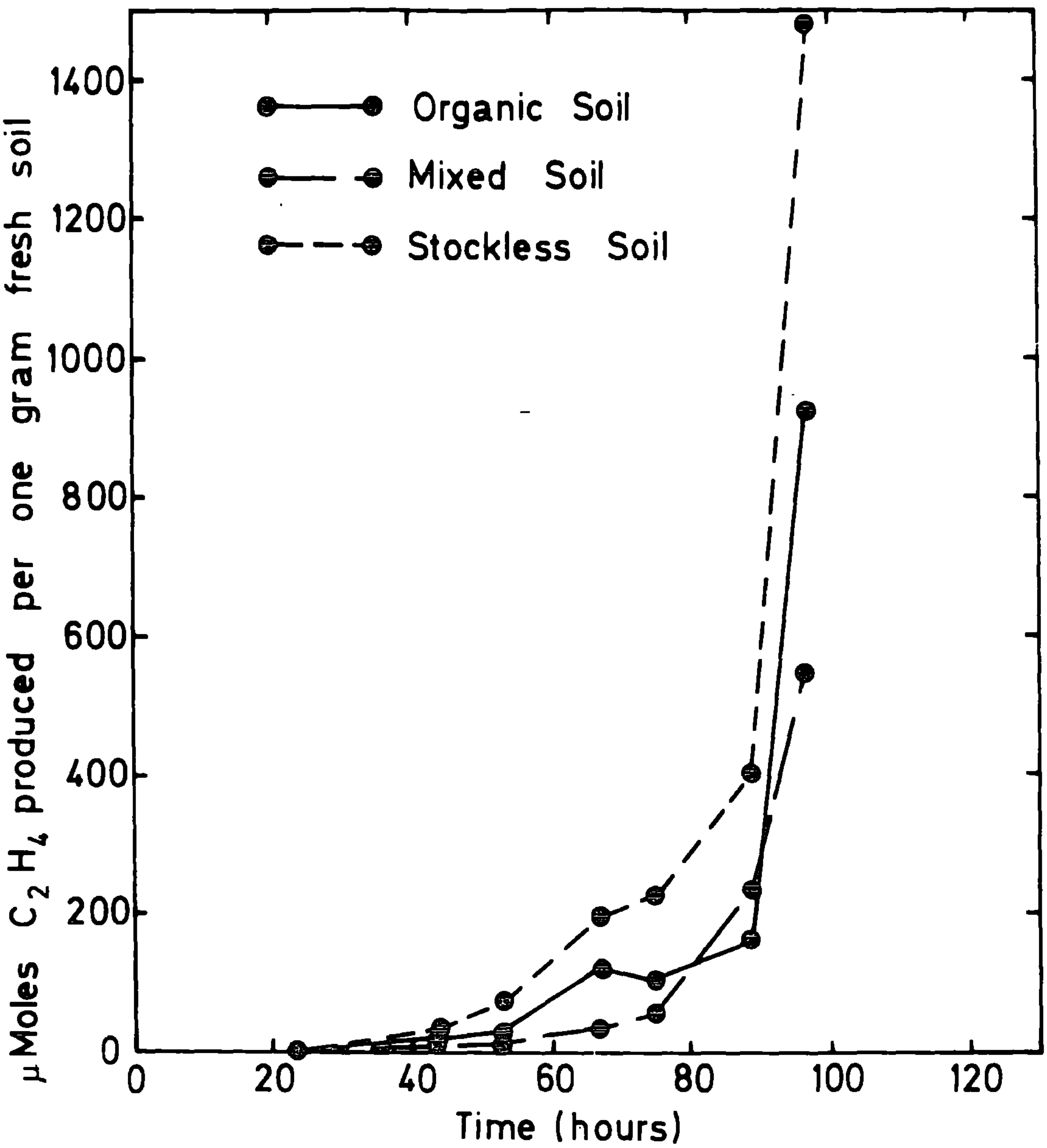


FIG. **14** Time Course of Acetylene reduction by soil micro organisms in different types of soil, June 1973, Soil samples were incubated in an average 12°C, with 2·5ml. of 5% Glucose.

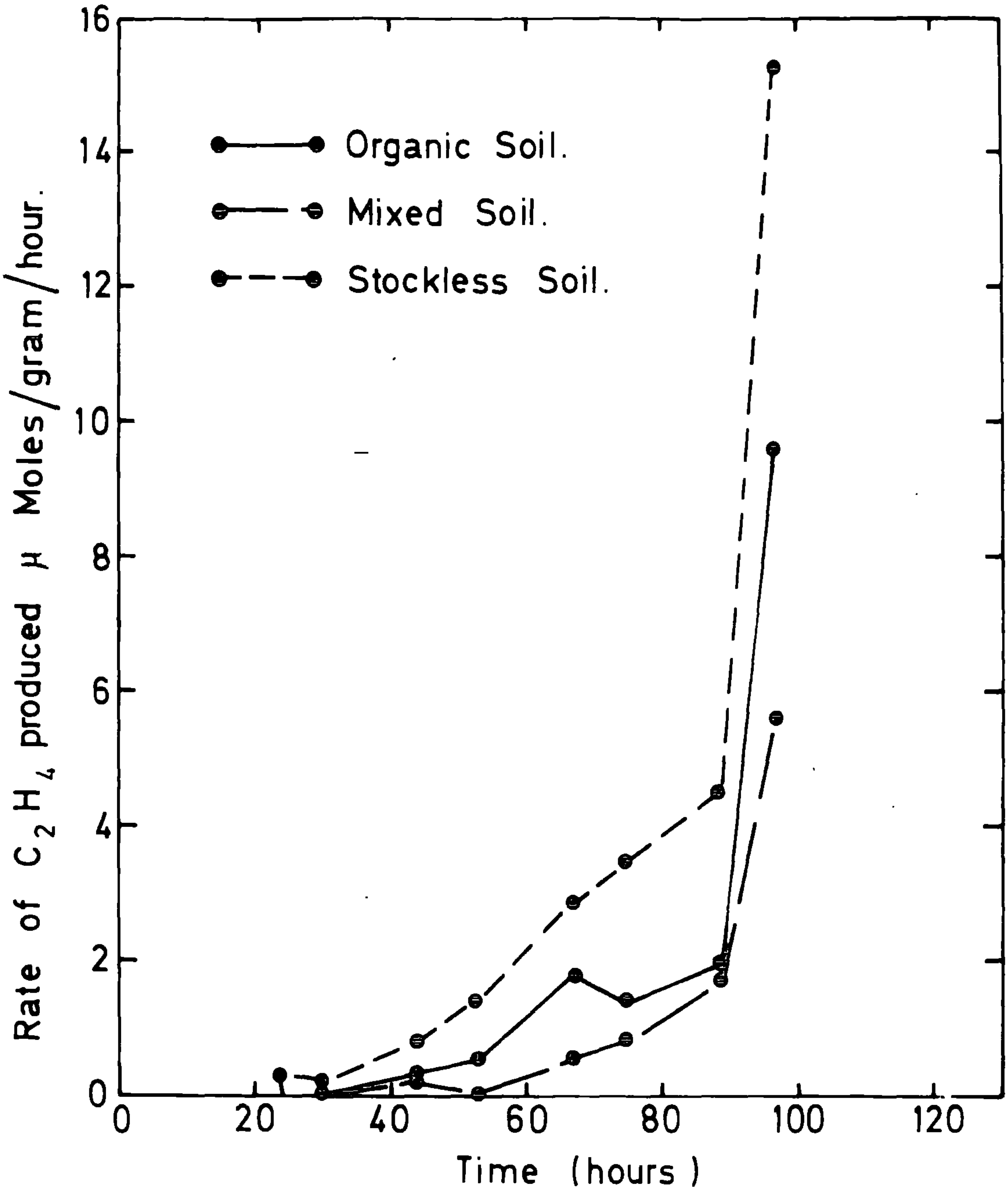


FIG. 15 Time Course of Acetylene reduction by soil micro organisms in different types of soil. June 1973. Soil samples were incubated in an average 12°C with 2·5ml. of 5% Glucose.

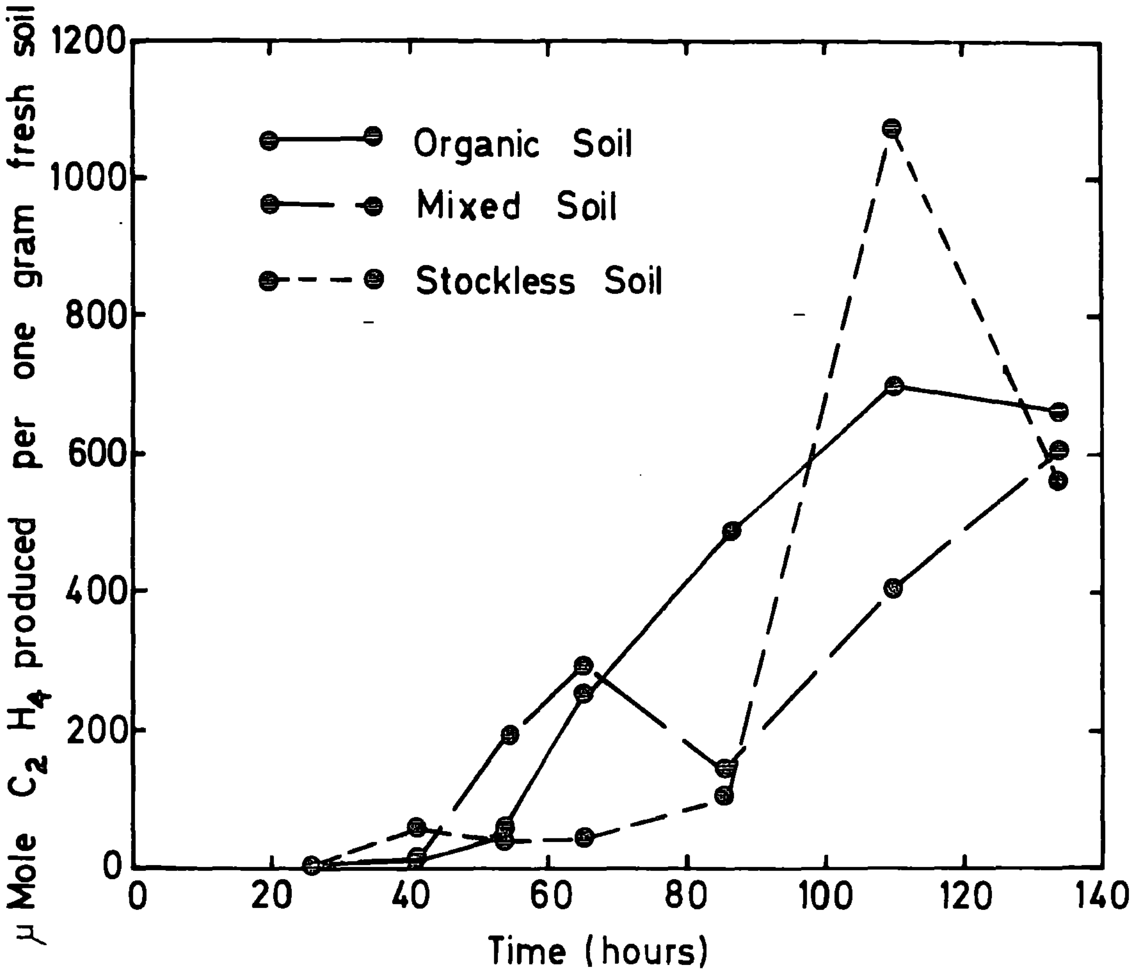


FIG. **16** Time Course of Acetylene reduction by soil micro organisms in different types of soil. August 1973. Soil samples were incubated in an average 12°C, with 2·5 ml. of 5% Glucose.

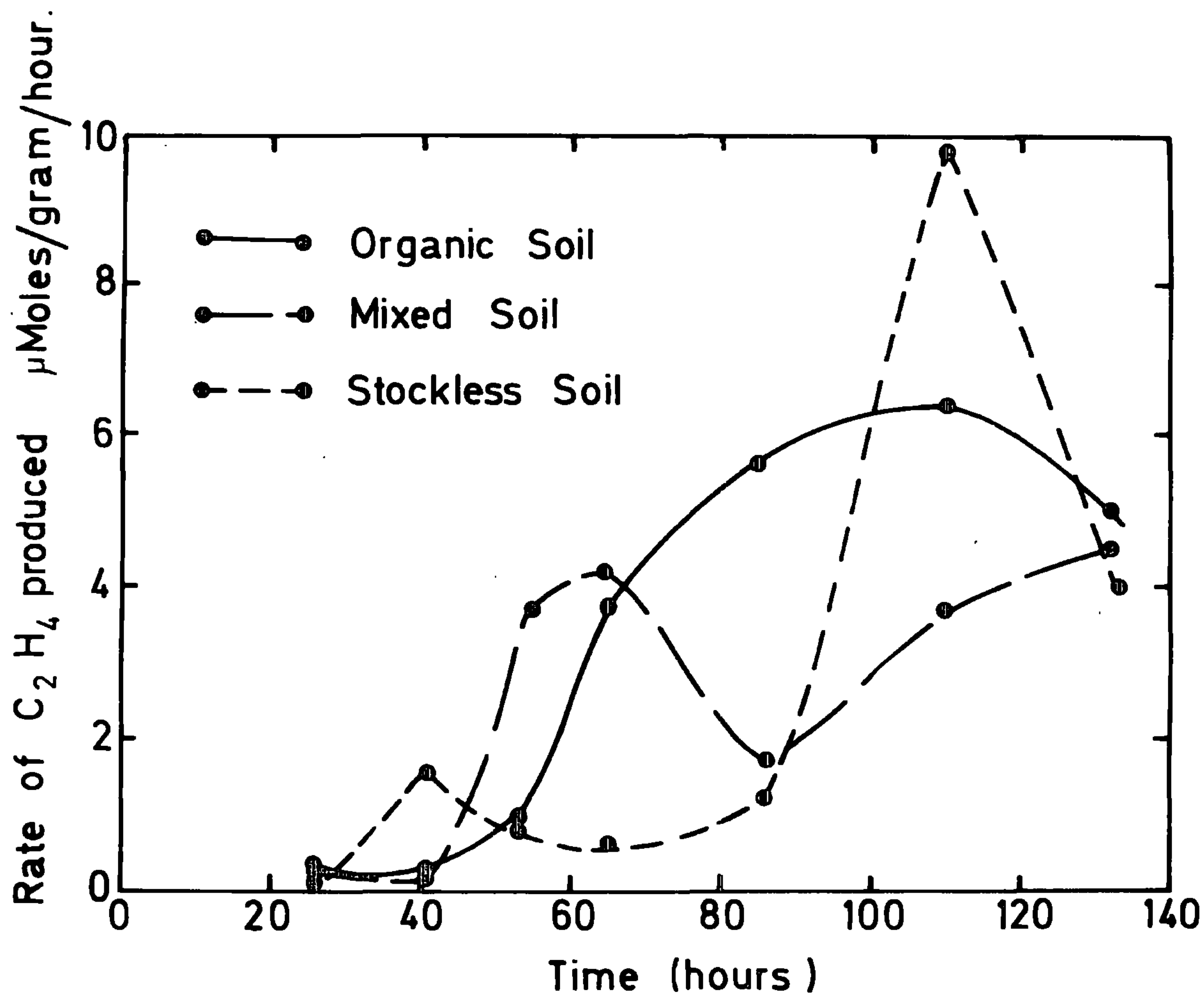


FIG. 17 Time Course of Acetylene reduction by soil micro organisms in different types of soil. August 1973. Soil samples were incubated in an average 12°C with 2·5 ml. of 5% Glucose.

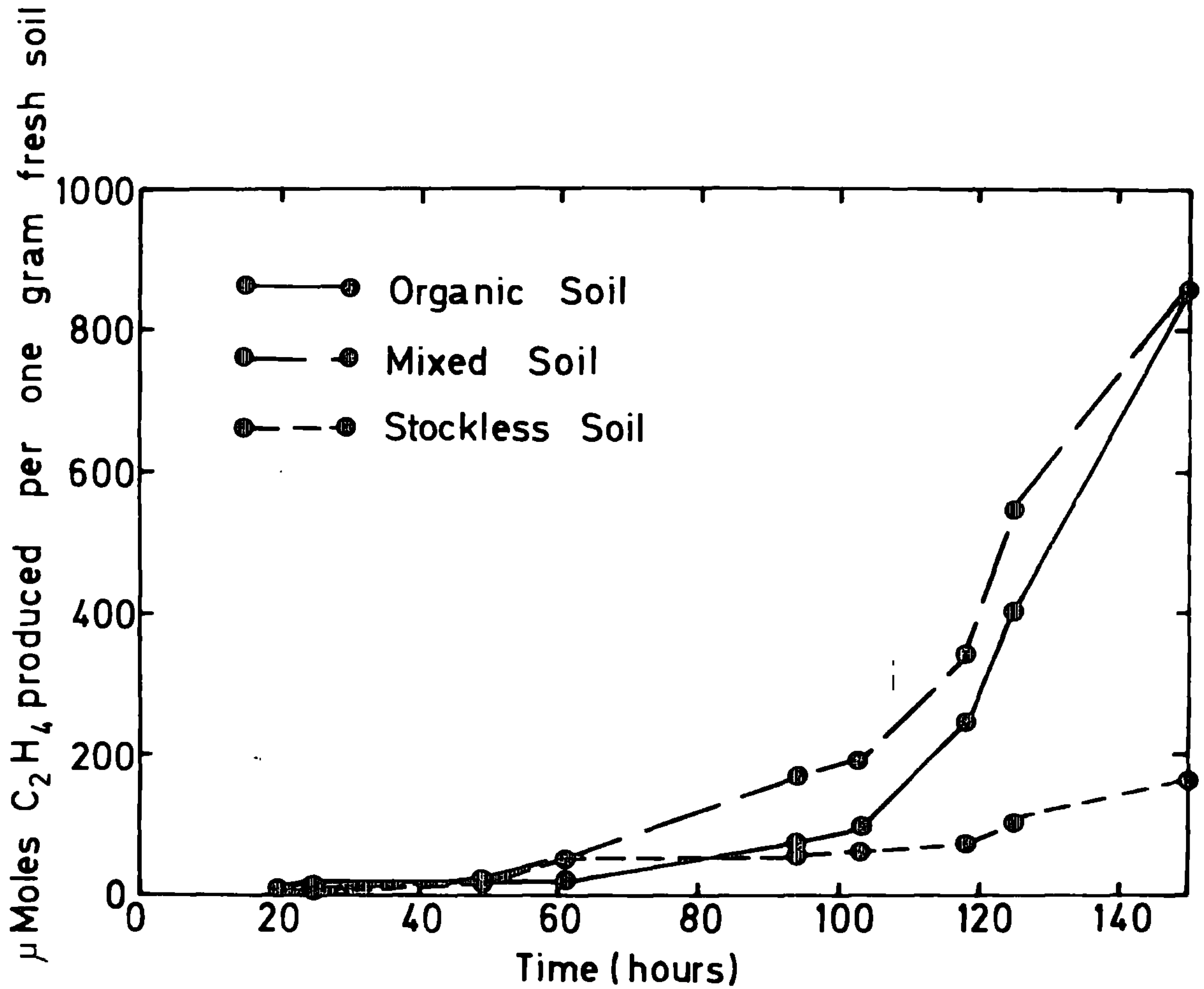


FIG. 18 Time Course of Acetylene reduction by soil micro organisms in different types of soil. September 1973. Soil samples were incubated in an average 12°C with 2·5 ml. of 5% Glucose.

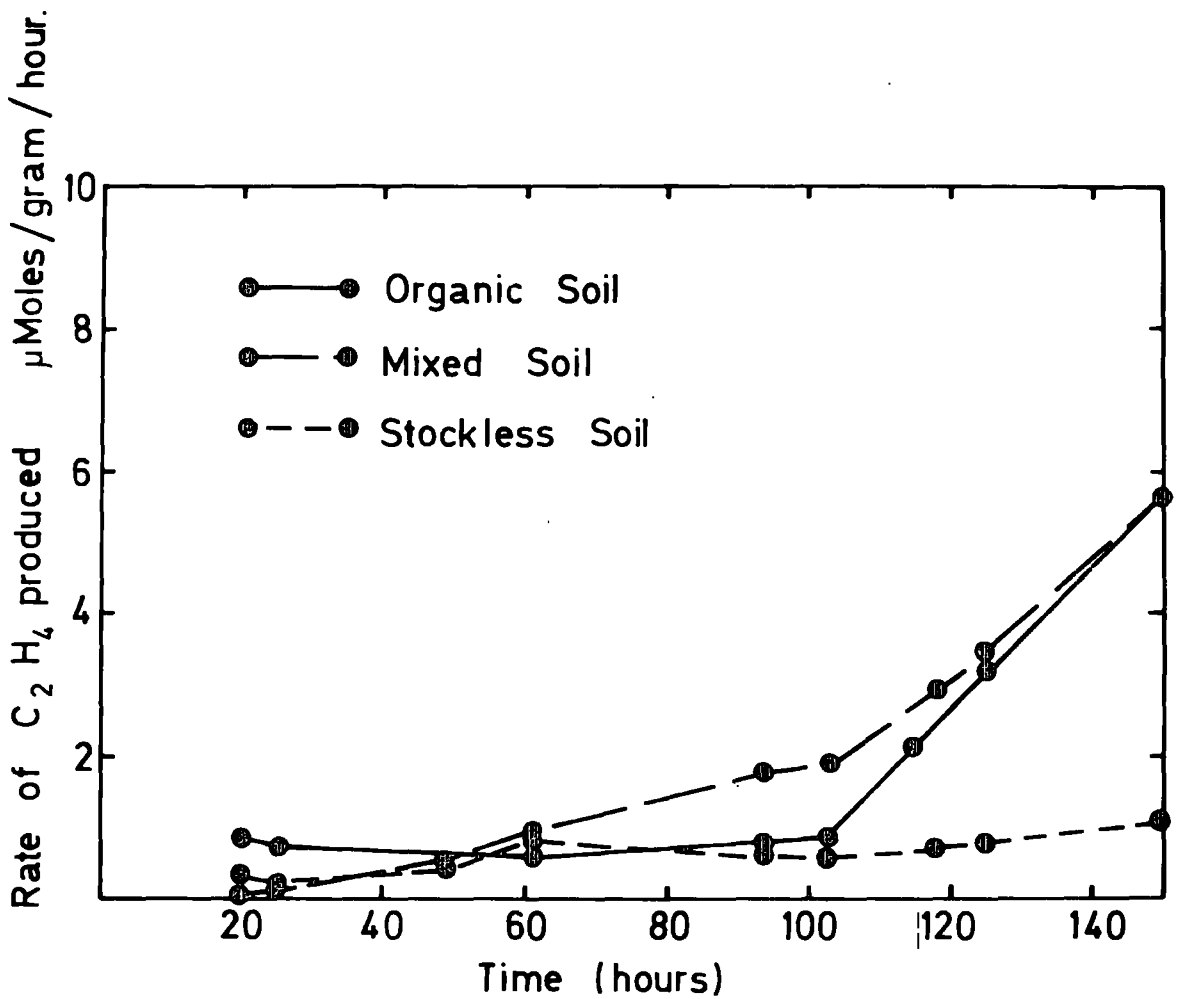


FIG. 19 Time Course of Acetylene reduction by soil micro organisms in different types of soil. September 1973 soil samples were incubated in average 12°C with 2·5ml. of 5% Glucose.

potential fixation is highest in the Stockless field. The Mixed soil consistently shows the lowest value and the Organic field shows intermediate potential. Significant differences were only maintained between the Stockless and the Mixed soil.

(B) Losses from the Systems

From the results of the lysimeter experiments, it is possible to calculate figures for the following:- (1) losses from the system in gravitational (drainage) water; (2) Losses removed with the crop at normal harvest, with the losses during short-term storage measured as the maximum uptake by the crop; (3) Losses of specific nutrients due to denitrification.

(1) Losses of Nutrients to gravitational (or ground) water

Introduction. Much work has been carried out in the past in an attempt to measure the losses of nutrients by crop systems to gravitational water, and hence to ground water outflow (Lawes *et al.*, 1882; Miller, 1906; Hendrick *et al.*, 1938; Johnston *et al.*, 1965; Wadleigh, 1968). More recently, detailed studies have been undertaken at Rothamsted by Williams (1970).

All indications to date are that appreciable proportions of the nutrients added (in whatever way) to the farm systems are lost to the drainage water. It was, therefore, decided to attempt comparisons of the three different farm systems. A further experiment was also instituted on the Stockless field in which the soils in some of the lysimeters were treated with high levels of N.P.K. fertilizers.

Methods. For full details of the methods, see Appendix V. The results allowed comparison of, (a) the chemical composition of the drainage water of the three systems; (b) Total losses of nutrients from the three systems.

(a) Comparison of the concentration of geochemicals in the gravitational waters

Results. The means and ranges of the concentrations are shown in Table 36, and the results of the nutrient concentrations in Figs. 20 to 27. The statistical analysis of the data is shown in Table 36a.

Conclusion. In all different field lysimeters the concentrations of all nutrients showed an increase in the second month of the experiments (May), because of the addition of the fertilizers.

After May all lysimeter types showed a decrease in their nutrient concentrations either as a result of being taken up by the crop or by leaching or other biological activity, until the period between September and December, when the concentrations showed an increase. (The highest levels attained are shown in the cropped lysimeters, probably due to the residues of the crop). From then until the end of the experimental period, the concentration of all nutrients fell, in all lysimeters.

TABLE 36

Chemical Composition of Drainage Water from Different Field Lysimeters

Nutrient		ORGANIC FIELD				MIXED FIELD			
		Cropped		Fallow		Cropped		Fallow	
		S	D	S	D	S	D	S	D
NO_3-N	M	3.64	7.2	6.78	6.38	3.3	7.8	7.0	6.7
	R	0.45-12.5	3.3-10.9	1.3-11.4	3.3-10.6	0.7-10.1	2.0-13.4	2.2-10.7	2.2-8.8
N	M	32.33	41.8	32.97	35.5	27.9	32.7	29.3	15.0
	R	21.2-53.0	20.1-50.9	22.1-47.7	21.2-47.7	22.2-42.0	22.2-42.4	21.2-42.4	21.2-85.0
K	M	6.37	1.75	6.38	1.3	2.3	3.6	1.7	1.13
	R	2.5-12.8	0.9-4.5	3.5-10.8	0.6-2.5	0.3-6.0	0.6-11.5	0.4-4.3	0.6-2.5
Ca	M	66.9	117.0	87.2	109.9	67.1	58.2	89.3	99.8
	R	35.0-107.5	51.0-224.0	51.0-137.5	61.0-177.5	43.5-138.0	50.0-124.0	64.0-136.5	77.0-128.0
Mg	M	4.09	4.7	5.32	3.4	3.6	4.2	4.4	3.4
	R	2.5-8.0	3.2-7.3	3.0-7.0	1.8-3.9	2.0-4.1	2.2-5.5	3.0-5.8	2.0-4.0
Na	M	10.13	10.4	10.57	13.72	6.5	6.9	7.0	6.9
	R	6.0-15.7	7.6-16.1	7.3-12.9	7.5-21.4	2.8-11.5	4.9-8.5	2.0-11.0	5.6-7.9

Nutrient		STOCKLESS FIELD				STOCKLESS FIELD at High N.P.K.			
		Cropped		Fallow		Cropped		Fallow	
		S	D	S	D	S	D	S	D
NO_3-N	M	2.8	7.3	2.2	5.4	3.7	3.2	4.0	5.3
	R	0.2-9.7	5.6-9.0	0.3-10.8	0.5-13.0	0.5-7.8	0.8-6.4	0.2-9.2	0.5-12.8
N	M	35.4	25.9	32.9	30.9	41.6	34.98	34.9	31.2
	R	20.1-53.0	21.0-30.0	24.0-58.3	21.2-49.5	24.0-42.0	22.3-45.5	24.0-56.2	21.0-46.0
K	M	5.7	0.5	6.3	2.14	4.2	3.4	2.96	0.95
	R	1.5-8.5	0.6-1.0	3.6-12.0	0.7-4.5	1.5-15.5	0.7-3.3	0.4-5.0	0.1-2.3
Ca	M	54.6	74.8	77.5	119.2	59.6	105.8	73.7	65.8
	R	41.0-78.0	73.0-76.0	58.0-111.0	54.0-221.0	44.0-86.0	77.0-142.0	50.5-113.0	45.0-110.0
Mg	M	7.6	1.4	3.7	4.7	2.6	3.12	3.2	2.8
	R	1.7-4.0	1.0-1.8	2.8-4.8	2.5-7.8	1.5-4.0	2.0-4.1	1.8-4.3	1.5-8.3
Na	M	8.05	8.9	14.6	8.42	5.0	6.8	5.98	5.3
	R	3.1-10.8	7.1-10.6	6.0-10.6	3.8-14.7	3.9-14.5	5.0-16.3	5.0-11.2	2.8-8.0

M = Mean concentrations = mg/L

R = Range

Results for, The Means and Ranges of the nutrient concentrations = mg/L.

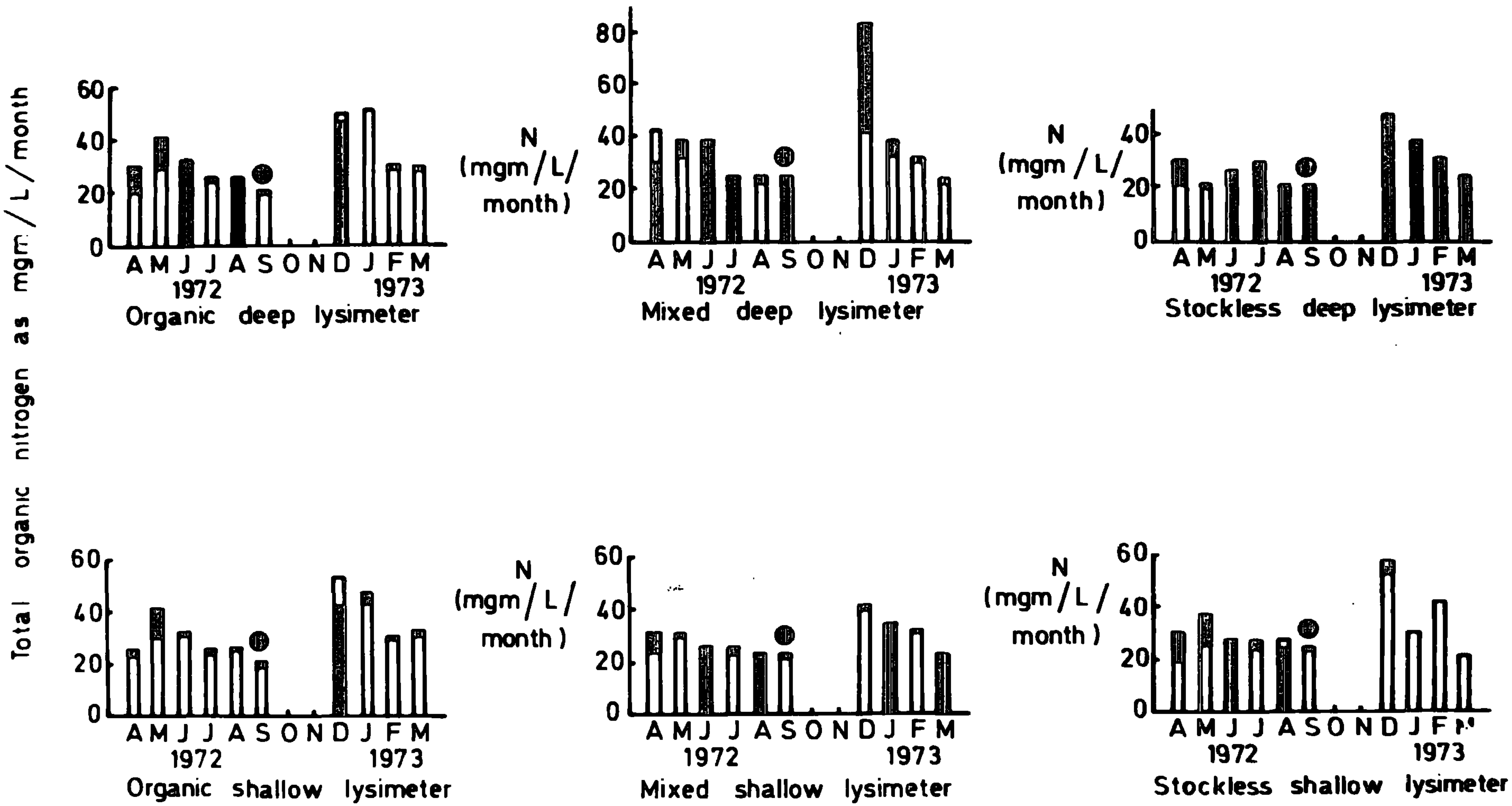


FIG. 20 Concentration of total organic nitrogen from individual drainage water from different field lysimeters (cropped lysimeter, fallow lysimeter.)

Harvest time.

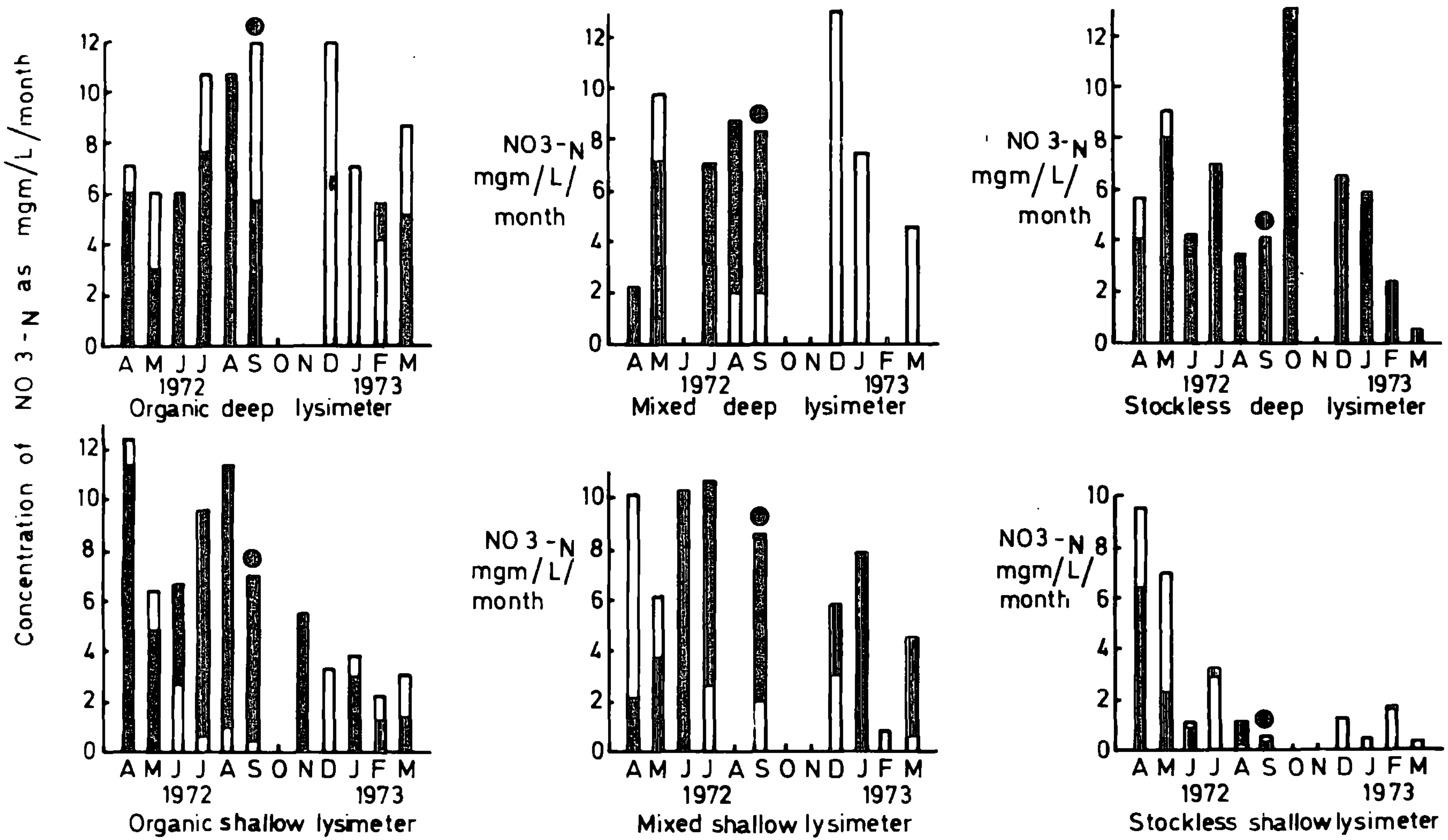


FIG.21 Concentration of Nitrate - Nitrogen from individual drainage water from different field Lysimeters (▭ cropped lysimeter, ▬ fallow lysimeter)
● Harvest time

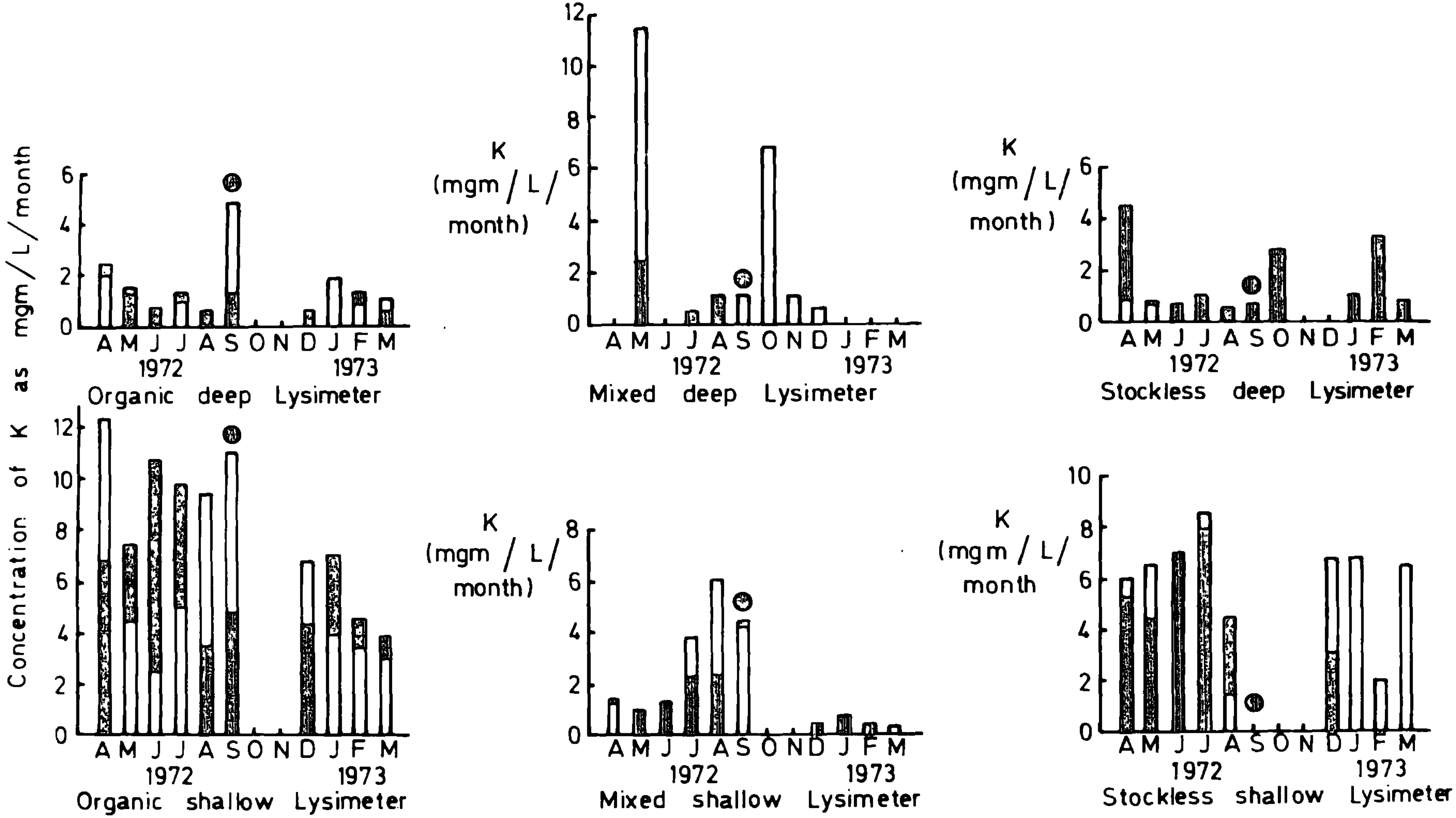


FIG.22 Concentration of Potassium from individual drainage water from different fields lysimeters (cropped lysimeter, fallow lysimeter.)

Harvest time.

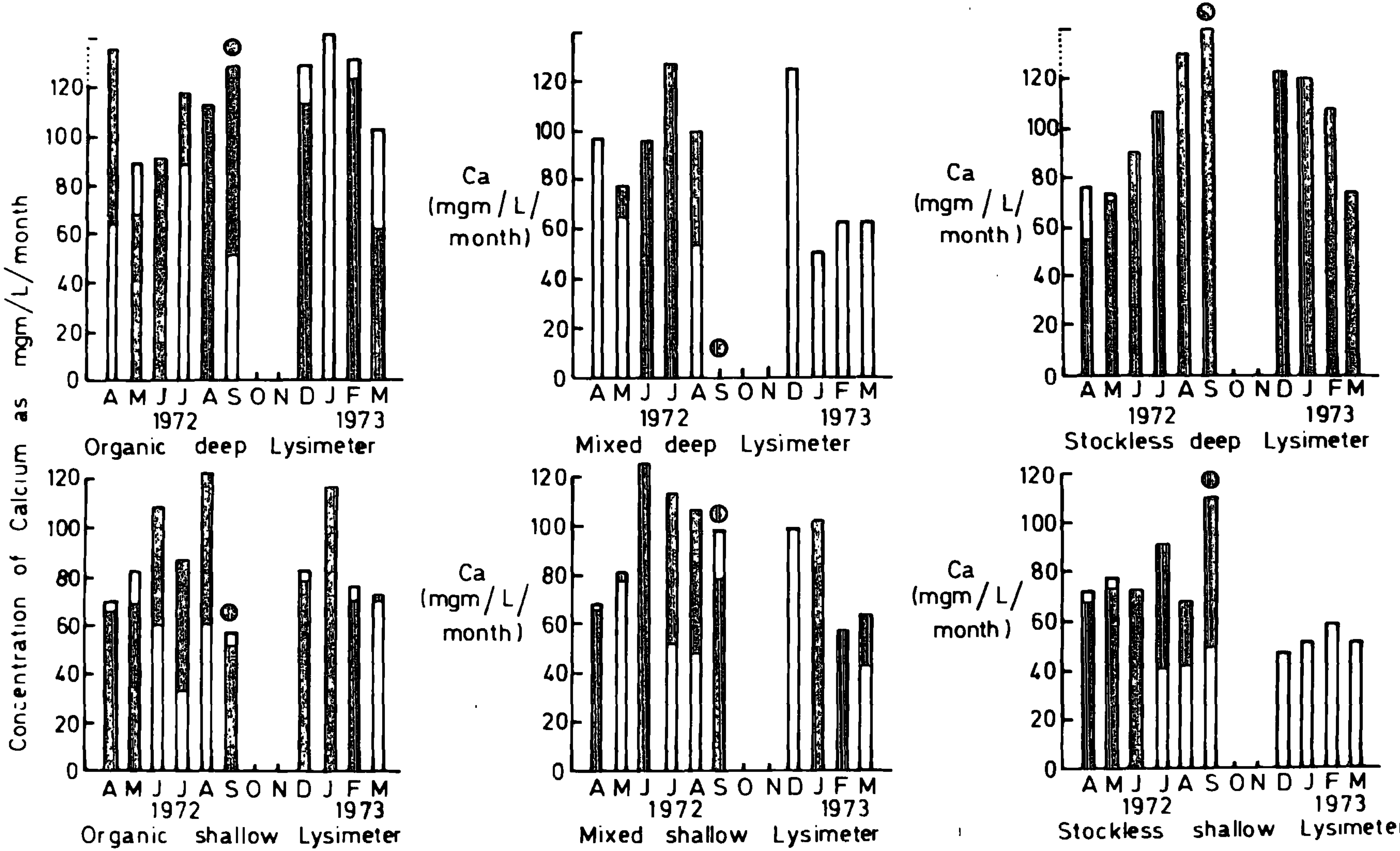


FIG. 23 Concentration of Calcium from individual drainage water from different field Lysimeters (▭ Cropped Lysimeter, ▩ Fallow Lysimeter) ⊕ Harvest time

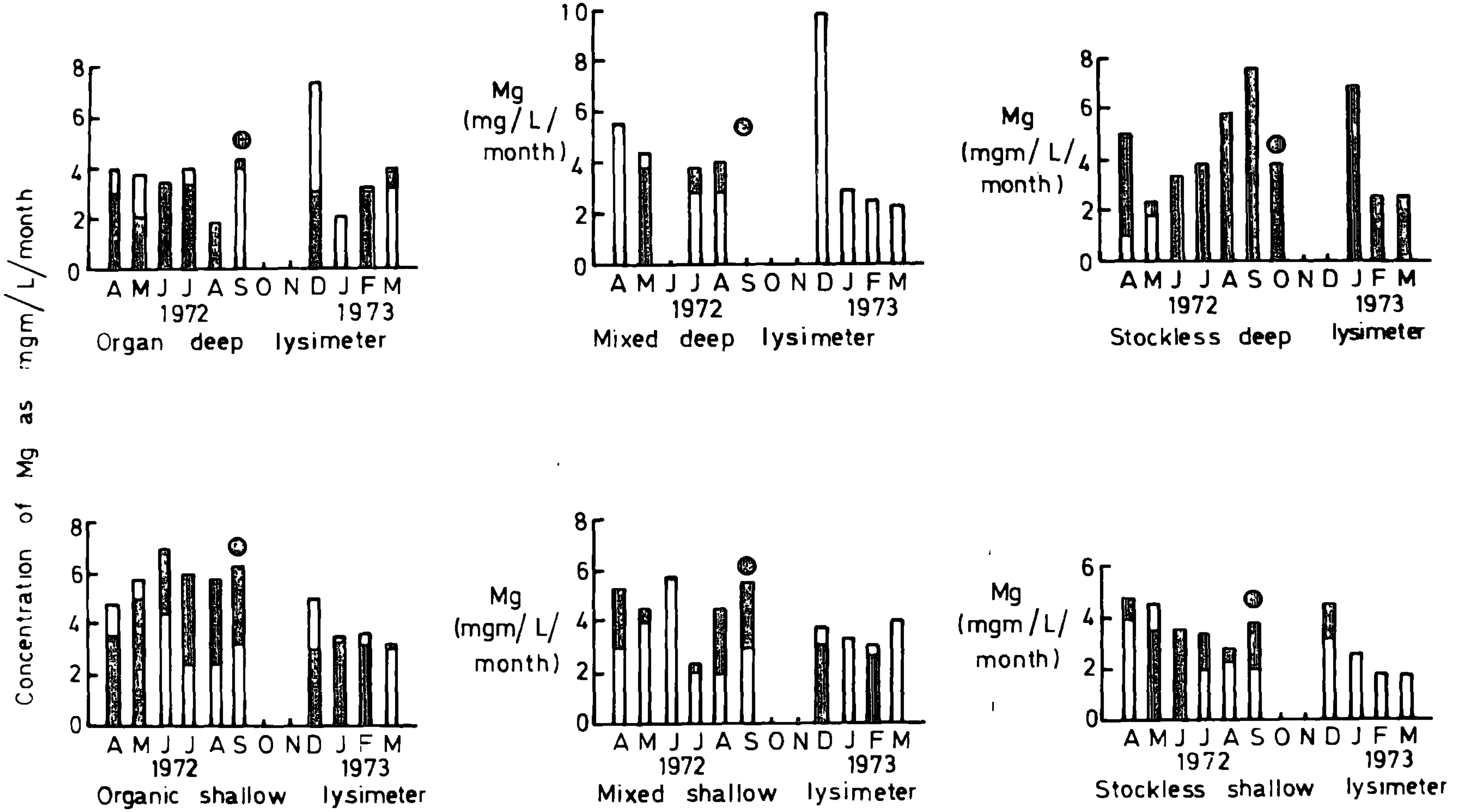


FIG. 24 Concentration of magnesium from individual drainage water from different field Lysimeters(cropped lysimeter, fallow lysimeter) ⊙ Harvest time.

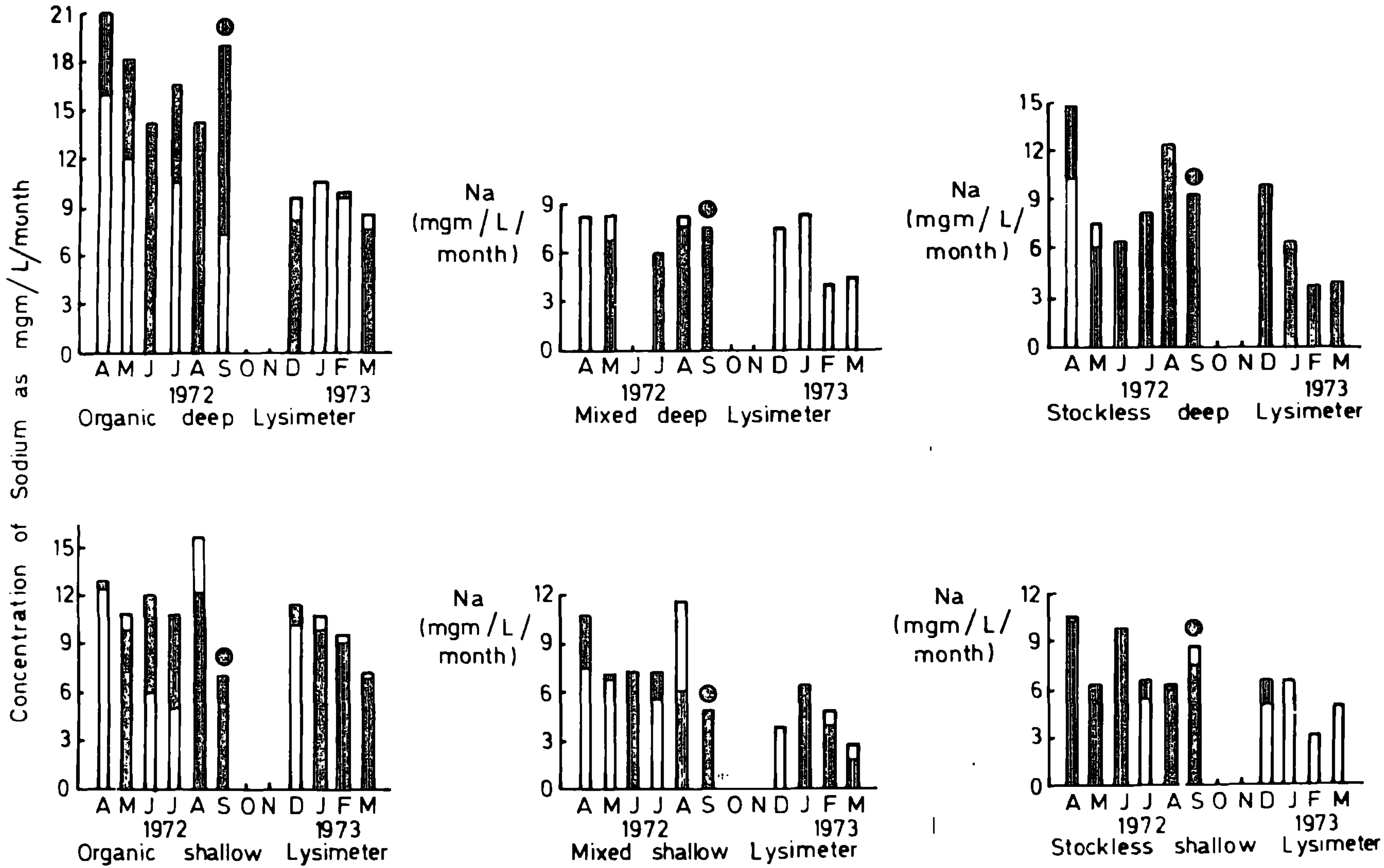


FIG. 25 Concentration of Sodium from individual drainage water from different field Lysimeters. (▭ cropped lysimeter, ▬ fallow lysimeter) ⊕ Harvest time.

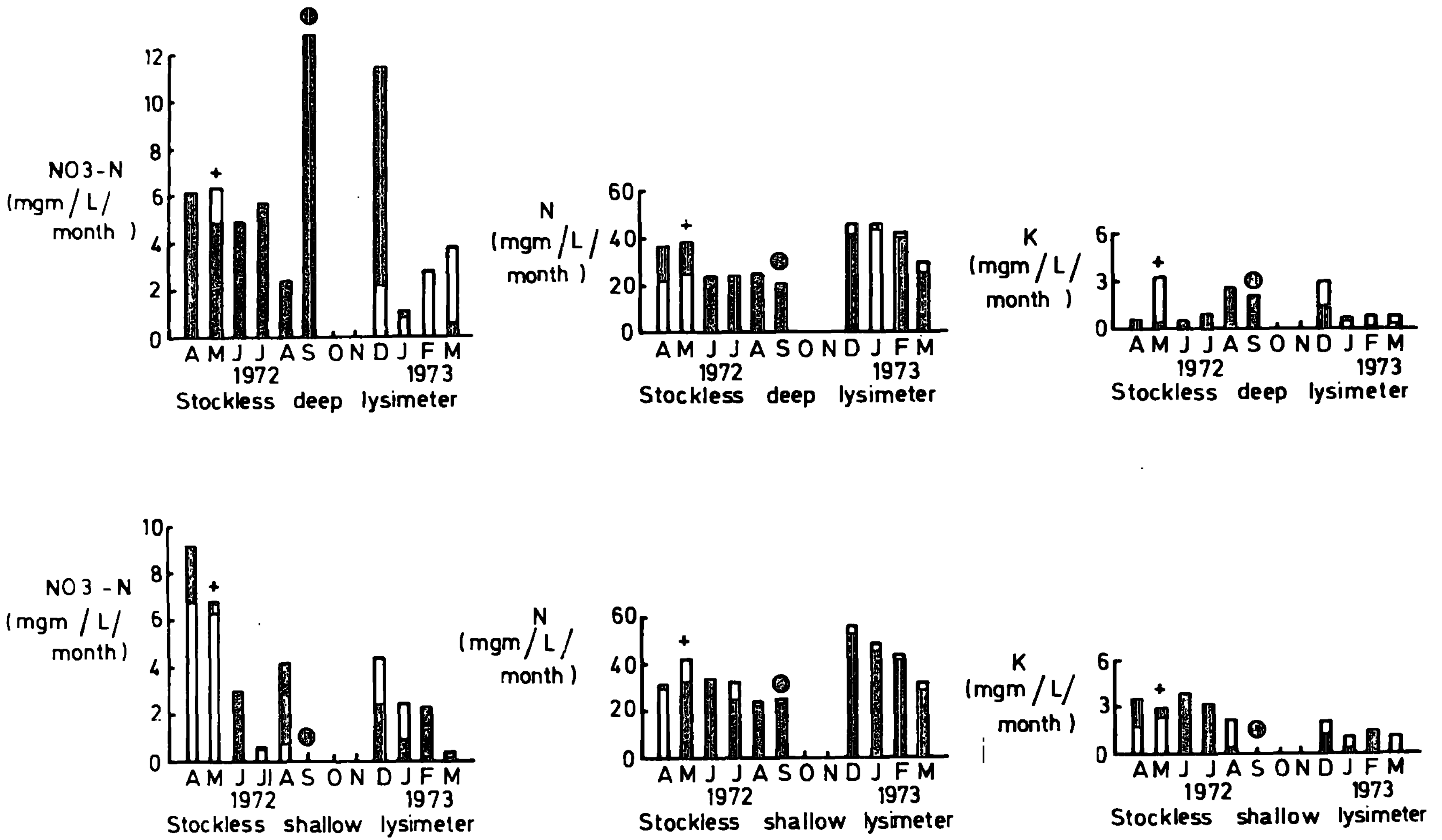


FIG.26 Concentration of nutrients from individual drainage water from stockless fields treated with fertilizer(89·8kg ha for deep lysimeter & shallow lysimeter)

▭ cropped ▬ fallow ⊛ Harvest time + Fertilizer added

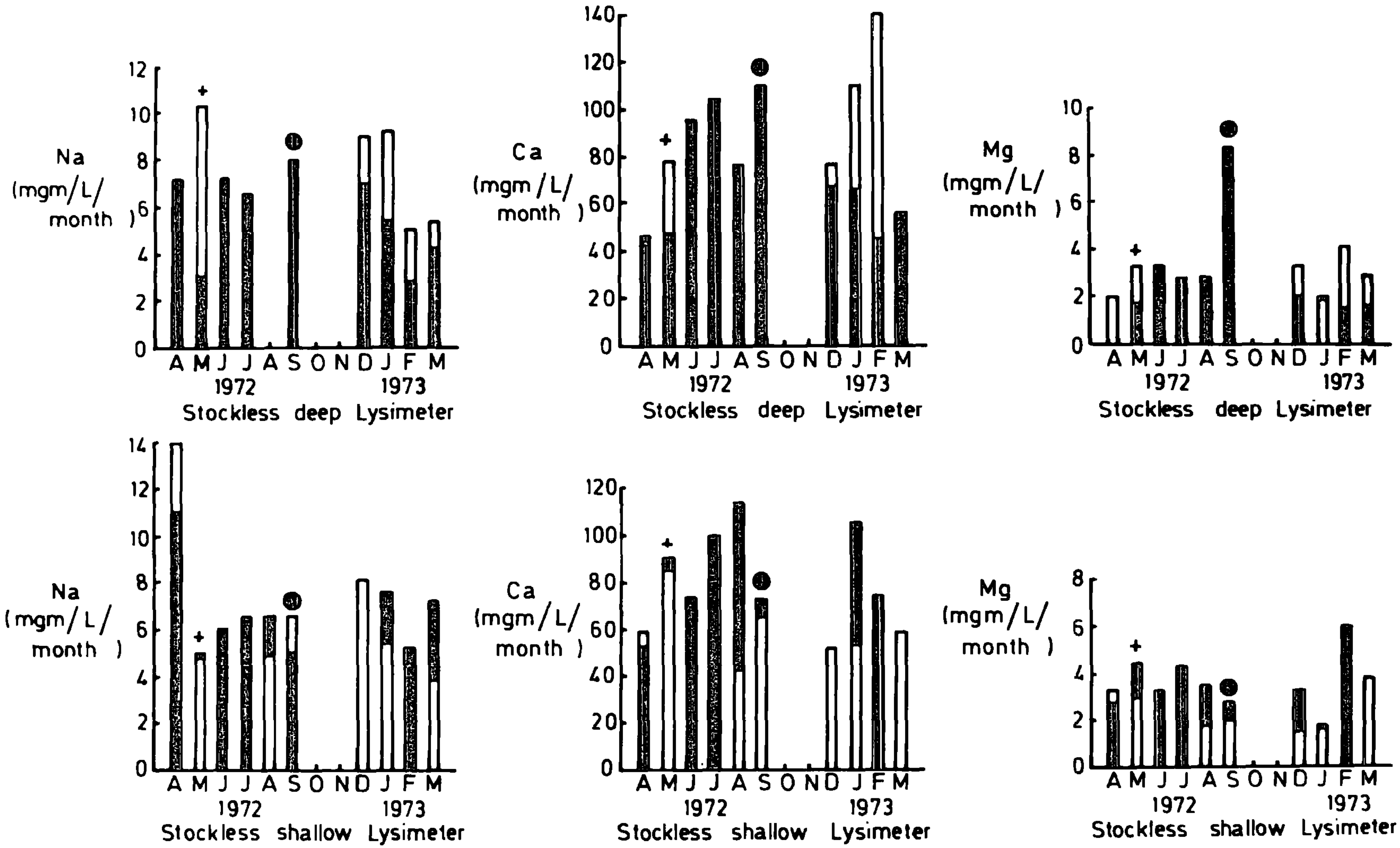


FIG. 27 Concentration of nutrients from individual drainage water from stockless field treated with fertilizer (89·8 kg/ha for deep and shallow lysimeters) ▫ cropped ▪ fallow

● Harvest time + Fertillizer added

TABLE 36a

Test of significance between the means of all nutrient concentrations in the drainage water of the different field lysimeters

Nutrient Details	Field type	Cropped Shallow t	P	R	Cropped Deep t	P	R	Fallow Shallow t	P	R	Fallow Deep t	P	R
NO3 - N	O - M	0.15	2.12	N.S.	0.02	2.36	N.S.	0.35	2.11	N.S.	0.21	2.11	N.S.
	O - S	0.58	"	N.S.	0.04	"	N.S.	0.02	"	N.S.	0.69	"	N.S.
	O - S+	1.05	"	N.S.	2.3	"	*	1.7	"	N.S.	1.2	"	N.S.
	M - S	0.42	"	N.S.	0.02	"	N.S.	0.92	"	N.S.	1.2	"	N.S.
	M - S+	1.3	"	N.S.	2.4	"	*	1.8	"	N.S.	1.3	"	N.S.
	S - S+	1.7	"	N.S.	2.2	"	*	1.8	"	N.S.	1.0	"	N.S.
N	O - M	1.2	2.12	N.S.	1.5	2.12	N.S.	1.3	2.12	N.S.	0.9	2.12	N.S.
	O - S	1.6	"	N.S.	13.3	"	*	1.4	"	N.S.	1.0	"	N.S.
	O - S+	1.3	"	N.S.	1.2	"	N.S.	1.1	"	N.S.	1.1	"	N.S.
	M - S	1.7	"	N.S.	12.7	"	*	1.9	"	N.S.	1.1	"	N.S.
	M - S+	1.5	"	N.S.	1.1	"	N.S.	1.2	"	N.S.	2.1	"	*
	S - S+	1.2	"	N.S.	1.4	"	N.S.	1.1	"	N.S.	1.0	"	N.S.
K	O - M	2.0	2.12	*	2.8	2.12	*	2.1	2.12	*	1.6	2.12	N.S.
	O - S	1.1	"	N.S.	6.7	"	*	1.2	"	N.S.	2.8	"	*
	O - S+	1.5	"	N.S.	1.9	"	N.S.	2.1	"	*	1.4	"	N.S.
	M - S	1.2	"	N.S.	18.8	"	*	2.4	"	*	1.8	"	N.S.
	M - S+	1.8	"	N.S.	1.1	"	N.S.	1.8	"	N.S.	1.2	"	N.S.
	S - S+	1.4	"	N.S.	6.8	"	*	2.1	"	*	2.3	"	*
Ca	O - M	1.9	2.12	N.S.	5.1	2.12	*	1.0	2.12	N.S.	1.7	2.12	N.S.
	O - S	2.3	"	*	2.8	"	*	1.5	"	N.S.	1.7	"	N.S.
	O - S+	1.1	"	N.S.	1.1	"	N.S.	1.2	"	N.S.	1.6	"	N.S.
	M - S	2.9	"	*	1.5	"	N.S.	1.5	"	N.S.	2.8	"	*
	M - S+	1.1	"	N.S.	1.8	"	N.S.	1.2	"	N.S.	1.5	"	N.S.
	S - S+	1.1	"	N.S.	1.4	"	N.S.	1.1	"	N.S.	1.8	"	N.S.
Mg	O - M	1.0	2.12	N.S.	1.6	2.12	N.S.	1.6	2.12	N.S.	1.6	2.12	N.S.
	O - S	2.7	"	*	3.3	"	*	2.1	"	*	1.0	"	N.S.
	O - S+	1.5	"	N.S.	1.5	"	N.S.	1.6	"	N.S.	1.2	"	N.S.
	M - S	2.0	"	*	4.9	"	*	1.7	"	N.S.	1.6	"	N.S.
	M - S+	1.4	"	N.S.	1.4	"	N.S.	1.4	"	N.S.	1.2	"	N.S.
	S - S+	2.9	"	*	2.2	"	*	1.2	"	N.S.	1.7	"	N.S.
Na	O - M	1.0	2.12	N.S.	1.4	2.12	N.S.	1.3	2.12	N.S.	4.8	2.12	*
	O - S	1.9	"	N.S.	1.4	"	N.S.	1.1	"	N.S.	7.8	"	*
	O - S+	2.0	"	*	1.5	"	N.S.	1.8	"	N.S.	2.6	"	*
	M - S	1.4	"	N.S.	1.4	"	N.S.	1.4	"	N.S.	1.7	"	N.S.
	M - S+	1.3	"	N.S.	1.0	"	N.S.	1.2	"	N.S.	1.3	"	N.S.
	S - S+	1.6	"	N.S.	1.3	"	N.S.	2.4	"	*	1.5	"	N.S.

t = Students's
P = Probability value
R = Result of significance
* = Significance difference at 5% level
N.S = No significance difference

b) Comparison of the total losses in the gravitational water

The results for each individual Ion are considered separately under each heading, the results for the total loss in kilograms/hectare are recorded.

The significance test, between the mean loss of all different Ions, is shown in Table 37a. When differences are shown as *, they are significant at the 5% level.

Detailed results are shown in Table 37 - 42, the full data being presented in the Appendix. pages 266 to 271

Summary of the significant test between the mean losses of the Ions is shown below:

The following significant differences at the 5% level in the potential mean loss of nutrients to gravitational water were found:

Total organic nitrogen

Cropped deep O > S
Cropped deep M > S
Cropped deep S > S

Fallow deep O > M
Fallow deep S+ > O
Fallow deep S > M
Fallow deep S+ > M

Nitrate - Nitrogen

Cropped deep O > M
Cropped deep O > S
Cropped deep S+ > O
Cropped deep S+ > S

Fallow shallow M > O
Fallow shallow O > S+
Fallow shallow M > S
Fallow shallow M > S+

Fallow deep S+ > M

TABLE 37a

Test of significance between the means of all the nutrient lost from the different field lysimeters

utrient Details	Field type	Cropped Shallow			Cropped Deep			Fallow Shallow			Fallow Deep		
		t	P	R	t	P	R	t	P	R	t	P	R
NO3 - N	O - M	0.98	2.110	N.S.	2.69	2.11	*	4.10	2.11	*	1.59	2.14	N.S.
	O - S	1.27	"	N.S.	2.30	"	*	3.45	"	*	0.52	"	N.S.
	O - S+	0.07	"	N.S.	4.10	"	*	2.30	"	*	1.10	"	N.S.
	M - S	0.30	"	N.S.	0.31	"	N.S.	5.59	"	*	1.49	"	N.S.
	M - S+	1.70	"	N.S.	1.00	"	N.S.	3.10	"	*	2.90	"	*
	S - S+	1.50	"	N.S.	7.60	"	*	1.70	"	N.S.	1.40	"	N.S.
N	O - M	1.86	2.11	N.S.	0.04	2.11	N.S.	0.39	2.11	N.S.	4.11	2.11	*
	O - S	0.29	"	N.S.	2.76	"	*	1.29	"	N.S.	1.09	"	N.S.
	O - S+	1.20	"	N.S.	1.10	"	N.S.	1.10	"	N.S.	2.00	"	*
	M - S	1.67	"	N.S.	8.00	"	*	1.73	"	N.S.	2.72	"	*
	M - S+	1.60	"	N.S.	1.10	"	N.S.	1.10	"	N.S.	5.60	"	*
	S - S+	1.30	"	N.S.	37.80	"	*	1.60	"	N.S.	1.20	"	N.S.
K	O - M	3.42	2.11	*	0.50	2.11	N.S.	4.49	2.11	*	1.90	2.11	N.S.
	O - S	0.33	"	N.S.	3.57	"	*	0.71	"	N.S.	2.35	"	*
	O - S+	3.50	"	*	1.60	"	N.S.	2.10	"	*	1.20	"	N.S.
	M - S	3.14	"	*	1.40	"	N.S.	2.80	"	*	2.91	"	*
	M - S+	1.90	"	N.S.	1.12	"	N.S.	2.00	"	*	3.90	"	*
	S - S+	3.10	"	N.S.	98.00	"	*	1.80	"	N.S.	2.30	"	*
Ca	O - M	1.66	2.12	N.S.	0.34	2.12	N.S.	0.44	2.12	N.S.	1.83	2.12	N.S.
	O - S	0.15	"	N.S.	1.39	"	N.S.	0.98	"	N.S.	1.38	"	N.S.
	O - S+	1.40	"	N.S.	2.00	"	*	1.03	"	N.S.	1.20	"	N.S.
	M - S	1.56	"	N.S.	1.25	"	N.S.	1.37	"	N.S.	3.20	"	*
	M - S+	1.40	"	N.S.	1.50	"	N.S.	1.10	"	N.S.	3.20	"	*
	S - S+	1.40	"	N.S.	22.90	"	*	1.40	"	N.S.	1.30	"	N.S.
Mg	O - M	0.95	2.11	N.S.	0.30	2.11	N.S.	1.20	2.11	N.S.	0.53	2.11	N.S.
	O - S	0.85	"	N.S.	1.17	"	N.S.	2.80	"	*	1.19	"	N.S.
	O - S+	2.60	"	*	2.10	"	*	1.60	"	N.S.	1.30	"	N.S.
	M - S	0.23	"	N.S.	1.45	"	N.S.	1.89	"	N.S.	0.90	"	N.S.
	M - S+	1.40	"	N.S.	1.70	"	N.S.	1.30	"	N.S.	3.00	"	*
	S - S+	1.60	"	N.S.	52.00	"	*	1.20	"	N.S.	1.10	"	N.S.
Na	O - M	3.49	2.11	*	0.82	2.11	N.S.	0.87	2.11	N.S.	1.27	2.11	N.S.
	O - S	0.96	"	N.S.	1.50	"	N.S.	3.04	"	*	0.77	"	N.S.
	O - S+	1.80	"	N.S.	1.70	"	N.S.	1.60	"	N.S.	1.70	"	N.S.
	M - S	1.90	"	N.S.	4.51	"	*	1.71	"	N.S.	2.22	"	*
	M - S+	2.10	"	*	1.00	"	N.S.	2.40	"	*	2.20	"	*
	S - S+	1.30	"	N.S.	2.53	"	*	1.20	"	N.S.	1.00	"	N.S.

t = Students.
P = Probability value.
R = Result of significance.

* = Significance at 5% level.
N.S = No significance at 5% level.

<u>Potassium</u>

Cropped shallow	O > M
Cropped shallow	O > S+
Cropped shallow	S > M
Cropped deep	O > S
Cropped deep	S+ > S
Fallow shallow	O > M
Fallow shallow	O > S+
Fallow shallow	S > M
Fallow shallow	S+ > M
Fallow deep	O > M
Fallow deep	S+ > O
Fallow deep	S > M
Fallow deep	S+ > M

<u>Calcium</u>

Cropped deep	O > S+
Cropped deep	S+ > S
Fallow deep	S > M
Fallow deep	S+ > M

<u>Magnesium</u>

Cropped shallow	O > S+
Cropped deep	O > S+
Cropped deep	S+ > S
Fallow shallow	O > S
Fallow deep	S+ > M

<u>Sodium</u>

Cropped shallow	O > M
Cropped shallow	S+ > M
Cropped deep	M > S
Cropped deep	S+ > S
Fallow shallow	O > S
Fallow shallow	M > S+
Fallow deep	S > M
Fallow deep	S+ > M

Therefore, out of 144 possible comparisons, 41 showed significant differences at 5% level. These are summarized below:

O	>	M	=	6
M	>	O	=	1
O	>	S	=	6
S	>	O	=	0
O	>	S_+	=	4
S_+	>	O	=	3
M	>	S	=	3
S	>	M	=	5
M	>	S_+	=	2
S_+	>	M	=	5
S	>	S_+	=	0
S_+	>	S	=	6
				41

Out of the 41 cases in which significant differences were recorded, 16 showed significantly higher losses of geochemicals from the organic field, and 14 significantly higher losses of geochemicals from the high fertilizer treatment.

Thus it would appear that regarding the potential loss of geochemicals to the ground water and hence potential eutrophication of the ground water by geochemicals both the organic systems and high fertilizer treatments are more prone to such losses.

However, the lack of consistent differences between the untreated and high fertilizer treatment stockless soils is of interest, pointing to the fact that the significant differences obtained could be interpreted as no more than variation in the setting up of the lysimeters. This is also borne out by the overall variations of the results between lysimeter types and cropping regimes.

In the light of the inconclusive results, the interpretation of the figure for overall loss can only be regarded as of interest. They do however show that the greatest losses of all geochemicals were from the organic field followed by the stockless high fertilizer treatment with the losses from the mixed field being the lowest.

In the light of the overall variation and the low levels of significance obtained, it is impossible to draw any firm conclusions as to the effect of the three farm systems on the potential loss of geochemicals to the gravitational water.

Summary tablesfor the total loss and additions throughout one year's experiments in the three different systems, is shown in Fig. 43, and the losses and gains in the three systems are presented in Tables 42a to 42g in the Appendix. pages 272to 278

(2) Uptake by the Crop

In order to investigate both the short-term losses (that is the maximum amount taken up by the crop) and the permanent loss (that is the amount taken off at harvest), the crops taken from the lysimeters throughout the growing season were analysed for their component geochemicals.

It was decided to use a single phytometer, barley var. 'Julia', in the experiment rather than the cloned 'RIKA' barley, used in the main experiments. This was done to alleviate the problem of differences if any in the physiology of the cloned 'RIKA' varieties. In essence this experiment was a comparison of the three farm systems in relation to one phytometer.

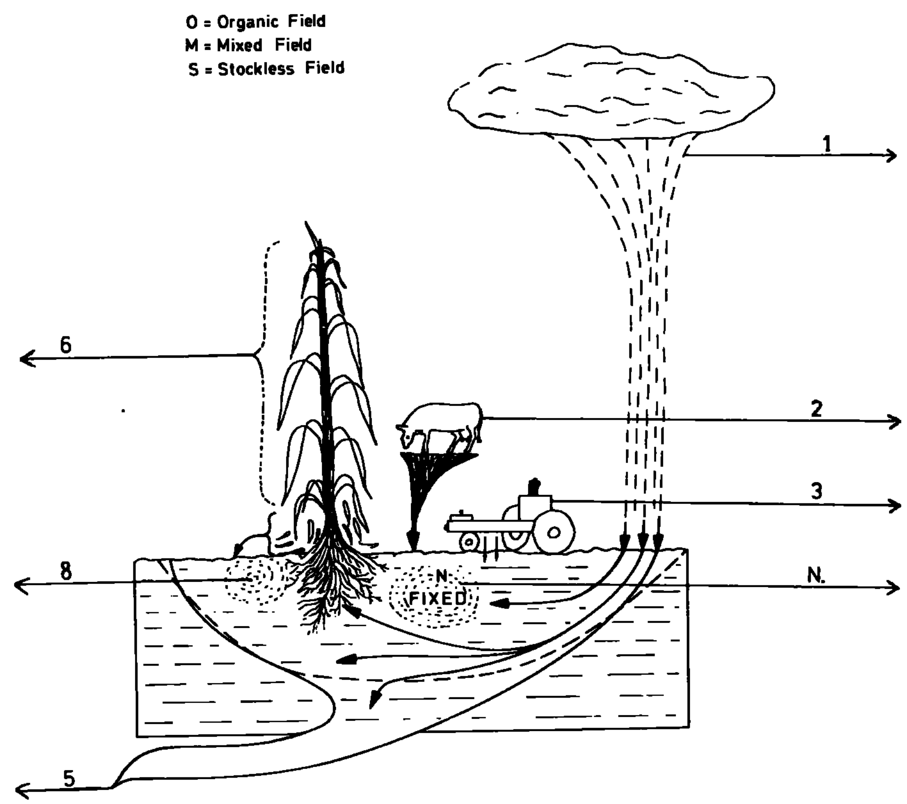
Results. The overall results are summarized in Tables 44 to 46 found in the Appendix pages 279-281, while the short-term loss of each geochemical is shown in Table 47.

The order of the amounts of the nutrients removed by the

LOSSES

NUTRIENT DETAILS	OUTPUT	CROPPED SHALLOW O	CROPPED SHALLOW M	CROPPED SHALLOW S	CROPPED DEEP O	CROPPED DEEP M	CROPPED DEEP S	FALLOW SHALLOW O	FALLOW SHALLOW M	FALLOW SHALLOW S	FALLOW DEEP O	FALLOW DEEP M	FALLOW DEEP S
NITRATE NITROGEN NO3-N	5	0·02	0·29	0·06	0·30	0·02	0·07	0·09	0·13	0·02	0·001	0·02	0·27
	6	4·65	1·14	0·64	4·65	1·14	0·64						
	7	0·5	0·23	0·05	0·5	0·23	0·05						
	8												
	T	0·51	0·78	0·06	0·30	0·25	0·30	0·09	0·13	0·07	0·05	0·02	0·27
ORGANIC NITROGEN N	5	0·20	1·45	0·37	1·10	0·12	1·43	0·39	0·39	0·25	0·03	0·26	1·90
	6	4·60	5·15	2·70	4·60	5·15	2·70						
	7	0·38	6·25	0·19	0·38	0·25	0·19						
	8	54·9	24·4	4·90	54·9	24·4	4·90	54·9	24·40	4·90	54·9	24·4	4·90
	T	55·49	56·70	55·20	56·00	24·80	26·00	24·80	24·80	5·30	5·10	5·20	6·80
TOTAL NITROGEN N	5	0·22	1·74	0·43	1·40	0·14	1·50	0·48	0·52	0·27	0·031	0·28	2·17
	6	9·25	6·29	3·10	19·26	2·21	0·97						
	7	0·88	6·48	2·75	5·10	5·38	2·75						
	8	5·49	24·4	4·90	54·9	24·40	4·90	54·9	24·40	4·90	54·90	24·40	4·90
	T	56·00	57·48	55·26	56·30	25·05	26·30	24·89	24·93	5·37	5·15	5·22	7·07
POTASSIUM K	5	0·05	0·05	0·06	0·05	0·01	0·07	0·01	0·02	0·04	0·01	0·05	0·14
	6	129·2	68·3	56·6	129·2	68·3	55·6						
	7	20·1	19·6	7·30	20·1	19·6	7·3						
	8												
	T	20·20	20·18	0·06	0·05	19·60	19·67	0·01	0·02	7·30	7·30	0·05	0·14
CALCIUM Ca	5	0·43	3·30	0·81	5·20	0·20	2·50	0·90	1·80	0·40	0·07	6·00	7·90
	6	27·60	36·4	23·7	27·60	36·4	23·7						
	7	41·19	21·47	21·53	41·19	21·47	21·53						
	8												
	T	41·50	41·60	0·81	5·20	~~21·70~~	23·97	0·90	1·80	22·10	21·60	6·00	7·90
MAGNESIUM Mg	5	0·09	0·37	0·10	0·47	0·02	0·21	0·15	0·12	0·06	0·009	0·05	0·28
	6	4·60	5·30	2·70	4·60	5·30	2·70						
	7	3·29	2·67	1·93	3·29	2·67	1·93						
	8												
	T	3·40	3·66	0·10	0·47	2·90	2·90	0·15	0·12	1·99	1·94	0·05	0·28
SODIUM Na	5	0·09	0·37	0·11	0·50	0·02	0·20	0·20	0·12	0·06	0·01	0·05	0·28
	6	23·10	4·10	4·10	23·10	4·10	4·10						
	7	4·10	5·80	0·51	4·10	5·80	0·51						
	8												
	T	4·19	4·10	0·11	0·50	5·80	6·00	0·20	0·12	0·57	0·52	0·05	0·28

LOSSES	
5	Lysimeter out Flow
6	Maximum up-take by crop
7	Removed at normal Harvest
8	Denitrification
T	Total output = Kg/ha/year



+ GAINS as Kg/ha/year	- LOSSES as Kg/ha/year

ADDITIONS

NUTRIENT DETAILS	INPUT	CROPPED SHALLOW O	CROPPED SHALLOW M	CROPPED SHALLOW S	CROPPED DEEP O	CROPPED DEEP M	CROPPED DEEP S	FALLOW SHALLOW O	FALLOW SHALLOW M	FALLOW SHALLOW S	FALLOW DEEP O	FALLOW DEEP M	FALLOW DEEP S
NITRATE NITROGEN NO3-N	1	0·87	0·87	0·87	0·85	0·85	0·85	0·87	0·87	0·87	0·85	0·85	0·85
	2												
	3	3·6	3·6		3·6	3·6		3·6	3·6		3·6	3·6	
	4	0·003	0·001	0·001	0·003	0·001	0·001						
	T	4·5	4·47	0·87	4·5	4·45	0·86	4·5	4·47	0·87	4·5	4·46	0·86
ORGANIC NITROGEN N	1	2·94	2·94	2·94	2·88	2·88	2·88	2·94	2·94	2·94	2·88	2·88	2·88
	2		19·2	19·2		19·2	19·2		19·2	19·2		19·2	19·2
	3	32.	32.		32.	32.		32.	32.		32.	32.	
	4	0·0012	0·00122	0·00114	0·0012	0·00122	0·00114						
	N.	39·87	25·98	73·9	39·87	25·98	73·9	39·87	25·98	73·9	39·87	25·98	73·9
	T	94·8	80·1	96·2	74·8	80·1	96·0	74·8	80·1	96·1	74·8	80·1	96·1
TOTAL NITROGEN N	1	3·81	3·81	3·81	3·73	3·73	3·73	3·81	3·81	3·81	3·73	3·73	3·73
	2		19·2	19·2		19·2	19·2		19·2	19·2		19·2	19·2
	3	35·6	35·6		35·6	35·6		35·6	35·6		35·6	35·6	
	4	0·0042	0·0022	1·001	0·0042	0·052	0·0021						
	N.	39·87	25·98	73·9	39·87	25·98	73·9	39·87	25·98	73·9	39·87	25·98	73·9
	T	99·3	84·6	97·1	79·3	84·6	96·9	79·3	84·6	96·9	79·3	84·6	96·9
POTASSIUM K	1	3·26	3·26	3·26	3·19	3·19	3·19	3·26	3·26	3·26	3·19	3·19	3·19
	2		72·9	72·9		72·9	72·9		72·9	72·9		72·9	72·9
	3	21·8	21·8		21·8	21·8		21·8	21·8		21·8	21·8	
	4	0·03	0·03	0·03	0·03	0·03	0·03						
	T	25·1	97·9	76·2	25·0	97·9	76·1	25·1	97·9	76·2	25·0	97·9	76·1
CALCIUM Ca	1	7·51	7·51	7·51	7·36	7·36	7·36	7·51	7·51	7·51	7·36	7·36	7·36
	2		3·3	3·3		3·3	3·3		3·3	3·3		3·3	3·3
	3	73·8	73·8		73·8	73·8		73·8	73·8		73·8	73·8	
	4	0·006	0·005	0·0053	0·006	0·005	0·0053						
	T	81·3	84·6	10·8	81·2	84·5	10·7	81·3	84·6	10·8	81·2	84·5	10·7
MAGNESIUM Mg	1	4·51	4·51	4·51	4·35	4·35	4·35	4·51	4·51	4·51	4·35	4·35	4·35
	2		1·1	1·1		1·1	1·1		1·1	1·1		1·1	1·1
	3	13·9	13·9		13·9	13·9		13·9	13·9		13·9	13·9	
	4	0·01	0·01	0·01	0·01	0·01	0·01						
	T	18·4	19·5	5·6	18·3	19·4	5·5	18·4	19·5	5·6	18·3	19·4	5·6
SODIUM Na	1	5·06	5·06	5·06	4·95	4·95	4·95	5·06	5·06	5·06	4·95	4·95	4·95
	2		1·1	1·1		1·1	1·1		1·1	1·1		1·1	1·1
	3	3·4	3·4		3·4	3·4		3·4	3·4		3·4	3·4	
	4	0·011	0·01	0·024	0·011	0·01	0·024						
	T	8·5	9·6	6·2	8·4	9·5	6·4	8·5	9·6	6·2	8·4	9·6	6·1

ADDITIONS	
1	Precipitation
2	Organic Fertilizer (manures)
3	Chemical Fertilizers
4	Seeds
N.	Nitrogen Fixation
T	Total input = Kg/ha/year

Type of Lysimeter \ Nutrient Details	NO3-N O	NO3-N M	NO3-N S	Organic N O	Organic N M	Organic N S	Total N O	Total N M	Total N S	K O	K M	K S	Ca O	Ca M	Ca S	Mg O	Mg M	Mg S	Na O	Na M	Na S
Cropped shallow	4·0	4·2	0·8	19·2	49·3	90·9	43·3	27·1	41·8	5·0	78·3	68·9	39·7	62·9	11·1	15·0	16·8	3·6	4·3	3·8	5·6
Cropped deep	7·3	4·3	0·8	18·1	55.	90·8	23·0	69·5	70·6	4·9	78·3	68·8	36·7	63·0	10·9	14·6	16·5	5·6	3·9	3·5	5·6
Fallow shallow	4·4	4·4	0.85	19·4	55·3	91·2	72·4	59·7	91·5	25·6	96·9	76·2	80·5	83·7	10·1	18·3	19·4	5·6	8·4	9·7	6·8
Fallow deep	4·5	4·3	0·6	18·7	55·3	89·3	74·1	79·4	89·8	24·9	97·9	76·9	76·0	82·7	2·9	17·3	19·3	5·2	7·9	9·5	5·8

FIG. 43 GEOCHEMICAL BALANCE SHEETS IN THE THREE DIFFERENT FARM SYSTEMS.

(ONE YEAR LYSIMETER EXPERIMENT AT HAUGHLEY FARM (SUFFOLK) 1973)

TABLE 47

Losses of Nutrients from Different Systems

Amounts taken off in crop at normal harvest, and also the amounts removed at maximum taken up (short-term storage)

Field Types \ Nutrient Details	NO_3-N	NO_3	N	K	Ca	Mg	Na
Organic	0.494	2.39	0.384	20.086	41.16	3.293	4.094
Mixed	0.230	1.02	0.250	19.560	21.47	2.667	5.805
Stockless	0.047	0.21	0.193	7.260	21.53	1.931	0.507

Amounts removed at maximum taken up by crop (short-term storage)

Organic	4.645	12.90	4.60	129.20	27.60	4.60	23.1
Mixed	1.140	3.95	5.15	68.30	36.40	5.30	4.1
Stockless	0.640	2.85	2.70	55.6	23.65	4.25	4.1

crop from the three different systems at normal harvest are:-

	Ca >	K >	Na >	Mg >	NO_3 >	NO_3-N >	Org.N	
Organic field cropped	41.2	20.1	4.1	3.3	2.4	0.5	0.4	Kg/ha
	Ca >	K >	Na >	Mg >	NO_3 >	Org.N >	NO_3-N	
Mixed field cropped	21.5	19.6	5.8	2.7	1.02	0.3	0.2	"
	Ca >	K >	Mg >	Na >	NO_3 >	Org.N >	NO_3-N	
Stockless field cropped	21.5	7.26	1.9	0.51	0.2	0.19	0.05	"

The amounts of the nutrients shown above indicated that the highest amounts lost at the normal harvest were from the Organic field, followed by the Mixed, and then by the Stockless fields.

On the other hand, the amounts of the nutrients taken up or removed at maximum by the crop as short-term storage, are shown below and are in this order:-

	K >	Ca >	Na >	NO_3 >	NO_3-N >	Org.N >	Mg	
Organic field cropped	129.2	27.6	23.1	12.9	4.65	4.6	4.6	Kg/ha
	K >	Ca >	Mg >	Org.N >	Na >	NO_3 >	NO_3-N	
Mixed field cropped	68.3	36.4	5.3	5.15	4.1	3.95	1.14	"
	K >	Ca >	Mg >	Na >	NO_3 >	Org.N >	NO_3-N	
Stockless field cropped	55.6	23.7	4.25	4.1	2.85	2.7	0.64	"

Also, the nutrients taken up at short-term storage are higher in the Organic field than the two others (Mixed and Stockless), except that calcium uptake in the Mixed field is higher than in the Organic field.

(3) Denitrification

Introduction. Many attempts have been made to determine the loss of nitrogen from the system due to denitrification the earliest being (Gayon & Dupetit, 1886). It has shown by Ferguson & Fred (1908) that denitrification in any soil was favoured by the addition of organic materials such as manures. Also, Oelsner (1918) reported that denitrification could occur in wet soils without the addition of the organic matter. The relations between denitrification and the organic matter and nitrates have been studied by Van Herson (1904).

Adel (1946) reported that nitrogen compounds in any soil decomposed as a result of the denitrification process. Shaw (1962) suggested that nitrogen was lost from heavy soil, not necessarily entirely by leaching, even more readily than from light soils. Also, he found that at 6 inches depth the soil was capable of denitrification, and one-third of the loss had occurred after five days and most was lost in ten days. The investigations have been carried out all over the world (Chapman *et al.*, 1949; Broadbent, 1951; Cooper & Smith, 1963).

It was decided to compare the loss of nitrogen by denitrification to the three different systems throughout one month's experiment.

Method. The method used is described in Section V.

Results. All the results are shown in Table 48, and are also presented in Figs. 29 and 30. The loss in the Organic and the Mixed fields were significantly greater than in the Stockless field (at 0 to 6 inches). For the analysis test of significance, see Table 49.

Nitrogen Denitrification

5 grams soil from different field systems, incubated with 4000 ppm. Nitrate Nitrogen (as KNO_3), at average of 25°C for 30 days.

(1) Soil from 0-6 in. depth.

Incubation time (days)	Organic Field			Mixed Field			Stockless Field		
	A	B	C	A	B	C	A	B	C
2	69.7 ± 3	6.7%	54.99	72.9 ± 2.0	7.2%	24.42	10.4 ± 0.3	0.9%	4.93
5	76.7 ± 1.8	7.4		84.0 ± 1.9	8.3		10.5 ± 0.8	1.0	
10	80.3 ± 2.3	8.7		87.0 ± 1.5	9.6		11.4 ± 1.0	1.1	
20	200.0 ± 0.8	19.2		88.7 ± 7.1	9.8		17.9 ± 1.2	1.8	
30	69.7 ± 4.9	6.7		87.2 ± 0.9	9.7		27.1 ± 1.1	2.2	

(2) Soil from 6-20 in. depth.

Incubation time (days)	Organic Field		Mixed Field		Stockless Field	
	A	B	A	B	A	B
2	17.7 ± 0.3	1.15%	12.2 ± 3.0	1.2%	9.0 ± 0.7	0.89%
5	14.7 ± 4.0	1.4	12.2 ± 3.0	1.2	14.9 ± 0.4	1.4
10	31.3 ± 14.0	3.0	21.0 ± 2.0	2.1	28.8 ± 0.3	2.9
20	28.7 ± 2.0	2.8	21.7 ± 1.0	2.2	22.9 ± 3.5	2.3
30	30.6 ± 6.0	3.0	48.2 ± 2.4	3.8	38.0 ± 1.3	3.8

A = Denitrified nitrogen = Ng/g fresh soil.

B = Rate of denitrification = Mg/g/day.

C = Amount of denitrified nitrogen = Kg/ha/season.

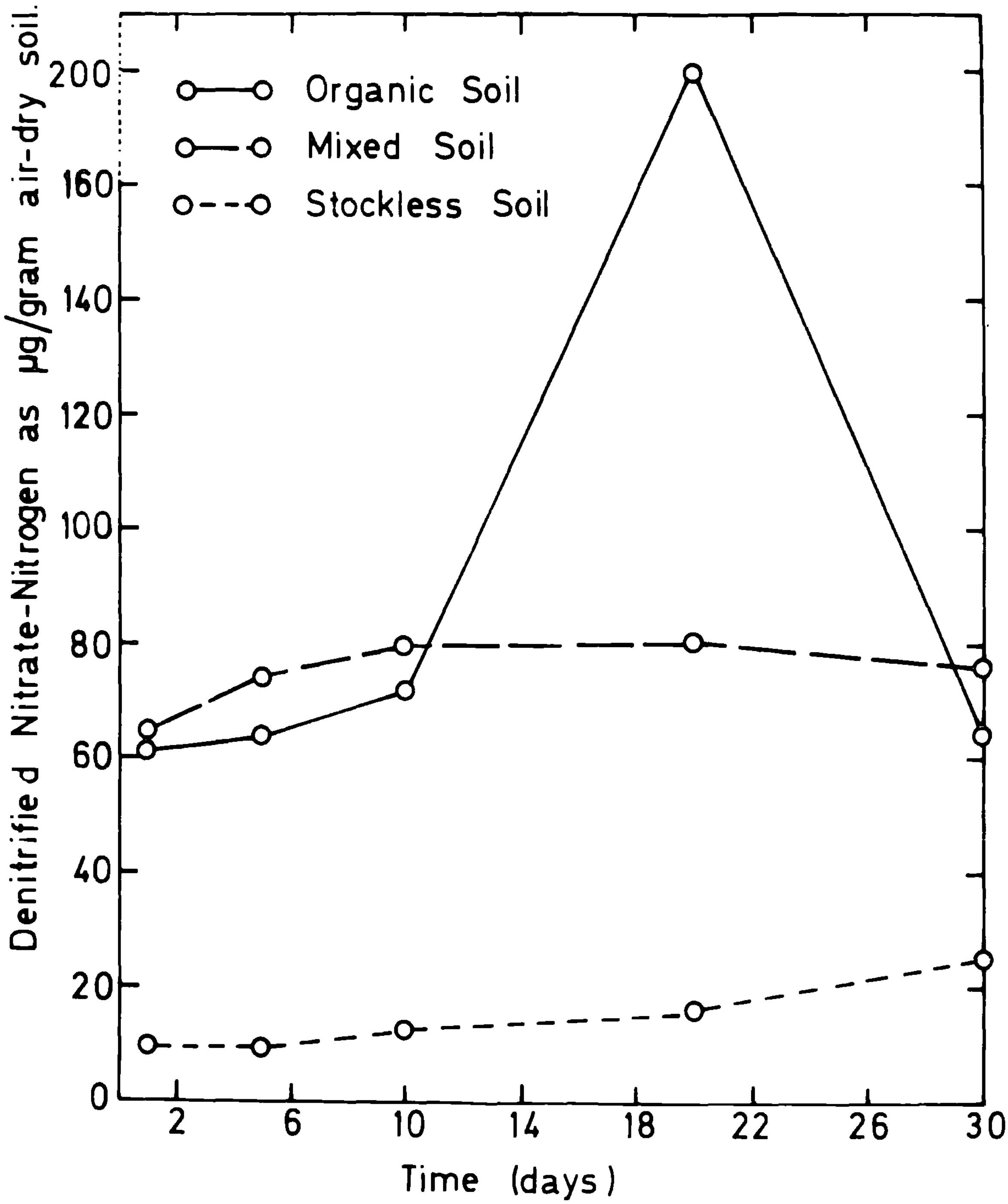


FIG. 29 Change in Nitrate-Nitrogen on incubation of 5 grams air-dry soil from 0-5 inches depth.

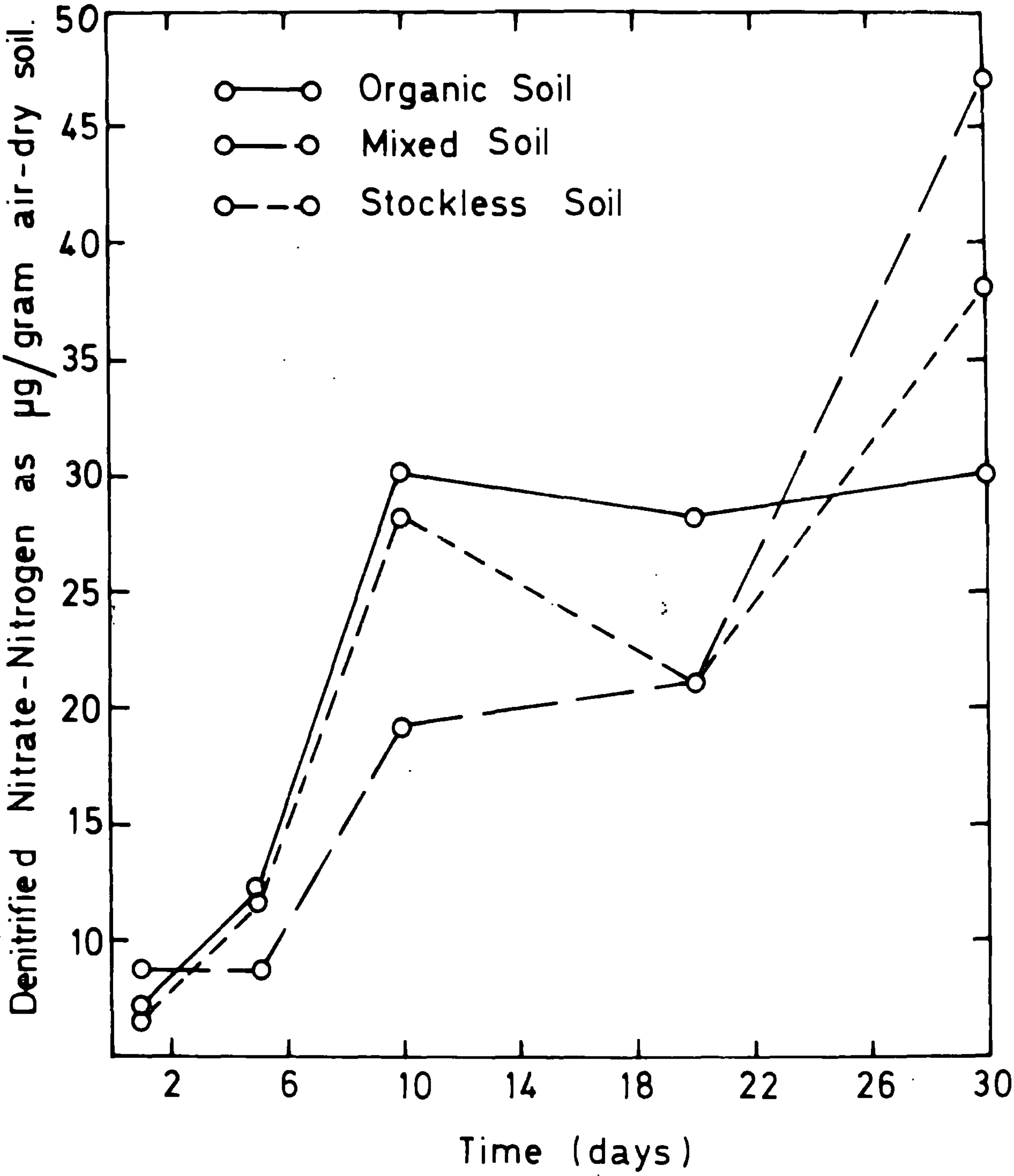


FIG. 30 Change in Nitrate-Nitrogen on incubation of 5grams soil from 6-20 inches depth.

TABLE 49

Nitrogen Denitrification

Test of significance between the maximum denitrification in the different field systems

Field Type	t	d.f	P	R
O - M	170.46	4	6.12	*
O - S	283.28	1	224.6	*
M - S	92.52	4	6.12	*

t = Students

d.f = Degrees of freedom

P = Probability value

R = Result of significance

* = Significance at 5% level.

INFERENCES DRAWN FROM THE RESULTS OBTAINED IN AN ATTEMPT TO CONSTRUCT THE GEOCHEMICAL BALANCE SHEETS

Nitrogen (potential fixation and Denitrification)

The higher levels of potential nitrogen fixation recorded for the Stockless soils are of interest. The explanation in all probability lies in the fact that the Stockless soils have significantly less nitrogen compounds (see Section 2) than either the Mixed or the Organic soils.

It has been shown (Russell, 1962) that the nitrogen fixation potential of soils is depressed where the levels of nitrogenous compounds rise in the soil system.

Similarly the significantly higher level of denitrification indicated for the Organic and Mixed systems are consistent with the higher levels of nitrogen compounds recorded for these soils.

The complete absence of any acetylene reduction under field conditions, that is using soil without added glucose, points to the fact that nitrogen fixation probably is of little importance in the Haughley systems.

Losses to Gravitational Water

Any attempted interpretation of the results from the lysimeter experiments must take into account the facts that:-

1. The soils used were of limited volume.
2. They had been removed from the original location in the fields with consequent disturbance.
3. The soils in the lysimeters are isolated from the natural fluctuation of phreatic and ground water in the field systems.

Bearing this in mind and also the irregularity and lack of pattern in the results any interpretation must be regarded with doubt. There is however, an indication of greater mobility of the geochemicals in the Organic and High fertilizer treatment Stockless systems, than in the others.

Out of the 41 recorded significant differences, 17 of these relate to nitrogen compounds, of which 6 gave the highest losses for the Organic systems and 6 from the high fertilizer treatment field.

This could be accounted for by the high level of nitrogen compounds in those soils.

Uptake by the Crops

Using the single barley variety 'Julia', comparison of both "short-term" uptake and "loss with crop" uphold the above. The use of a single phytometer indicates that in all cases (except for Ca short-term storage) the flux of geochemicals into the plant was greater in the Organic field, followed by the Mixed, followed by the Stockless fields. Unfortunately, these experiments were not repeated and therefore cannot be treated statistically.

Thus, it would appear on the basis of the lysimeter experiments that differences existed between the geochemicals of the three systems. These are summarized in Fig. 43.

SECTION 3. (1) COMPARISONS USING GROWTH ANALYSIS

GROWTH PHYSIOLOGY

It is difficult to say with certainty who first put forward the idea that the growth of plants can be regarded and analysed as a geometric progression. Chodat (1911) in the second edition of his "Principes de Botanique" certainly was conversant with the idea, applying it to a study of the sunflower, and Gressler (1907) used a method which he termed the quantitative analysis of plant growth.

An early attempt to analyse crop yield in terms of growth was made by Balls and Holton (1915), when studying cotton in Egypt. They measured the daily increases in height of the main stem and length of the other important organs. They reported difficulties especially in the early part of the flowering periods, which they attributed to fluctuations in the rate of stem growth.

A few years later, Engledow and Watson, (1923) working at Cambridge began their investigations on the yield of cereals. The method they used was to census all the characters of the growing crop which they considered to affect the yield. Measurements were made of the number of plants per unit area, number of tillers per plant, number of ears per plant, length of plant at harvest, and the number and weight of the grain.

Blackman (1919) published a now classic paper entitled "The compound interest law of plant growth". In this, he pointed out that increases in the dry weight can be likened to compound interest, the increase in any interval being added to the "capital" for growth in subsequent periods.

He also elucidated the relationship between the dry weight and time, and coined the term 'Relative Growth Rate', pointing out that the dry weight yield of any plant can be considered to be totally dependent on the initial seed weight (relative growth rate), and the length of the growth period (time). He thus indicated that comparative studies can be based on these quantities.

Briggs et al. (1920) made important advances in our understanding of the problems of growth analysis relating to what they called 'ontogenetic drift'. They regarded the use of the mean rate of increase as a function of Unit Leaf Area.

The rate of increase of the dry weight per Unit Leaf Area is a measure of the excess of the rate of photosynthesis over the rate of the dry matter lost by respiration (Watson, 1952). The first person who suggested the use of this function in the analysis of the growth was Gregory (1917). He called it 'Net Assimilation Rate', and it is clear that the Relative Growth Rate is the product of Net Assimilation Rate, and the ratio of the leaf area to the total dry weight; this ratio may be regarded as an index of the amount of growing materials per unit dry weight of the plants.

Much work has been carried out in the search for simpler and more efficient methods of growth analysis. All those described to date are based on harvesting at regular intervals. In such studies the samples have to be large enough to allow statistical treatment of the data to test that significant changes have taken place.

A procedure for improving the accuracy of estimation of the growth increases, designed to eliminate errors due to initial differences between samples taken at the beginning and the end of an interval, was used by Goodall (1945). The method, which deals with small samples, overcomes some of the difficulties related to the determination of plant growth when a considerable period has elapsed between one harvest and the next. Secondly, it might fit in better with laboratory organization, when much material has to be handled with limited facilities. This method has been fully investigated statistically by McIntyre and Williams (1949).

It was, therefore, decided to make such a series of determinations of Relative Growth Rate, Unit Leaf Area and Net Assimilation Rate, to investigate the growth physiology of the plants used in this study.

The methods followed were those of Hughes and Freeman

(1967), which allow comparative analysis of data gained from very small samples. This method was selected because it allows statistical comparison based on small samples, thus economising on both time and analytical effort and allowing more extensive comparisons of the three systems to be made.

Growth Physiology Analysis procedure for analysis of plant growth

The analytical procedure here is according to the method described by Hughes and Freeman (1967), and the final analysis of the growth patterns calculated using Hughes' programme, which at present is being modified for use on the Durham IBM360 and IBM1130 computer units.

The primary data required in this work are:- leaf areas and dry weights of the individual plants. The absolute variability of any plants increases as a result of the increasing plant size. The computer transferred the primary data to Logs, rendering the variability more homogenous with time. The polynomial of sufficient fit to the logarithms of the weights and areas on time is determined by the "Least Square Method", which makes the sum of the squares of discrepancies between the observed and fitted values, as small as possible.

A cubic is found adequate in both cases, logarithms of dry weights and leaf areas giving:-

$$\text{Log } W = W = a + bt + ct^2 + dt^3 \quad .... \quad (1)$$

$$\text{Log } A = A = e + ft + gt^2 + ht^3 \quad .... \quad (2)$$

Where W = dry weight (mg); A = leaf area (cn^2); t = time in days.

The classical analysis of the growth is:-

$$\text{Relative Growth Rate (R.G.R.)} = \frac{1}{W} \cdot \frac{dW}{dT}$$

$$\text{Leaf Area Ratio (L.A.R.)} = \frac{A}{W}$$

$$\text{Net Assimilation Rate (N.A.R.)} = \frac{1}{A} \cdot \frac{dW}{dT}$$

which are interrelated as R.G.R. = L.A.R. x N.A.R.

The progression for Relative Growth Rate against time can then be derived by differentiation from equation (1) for:-

$$d\,\frac{(\log\ W)}{dT} = \frac{1}{W} \cdot \frac{dW}{dT} \quad .... \quad (3)$$

The progression for Relative Leaf Growth rate can be derived similarly from equation (2) for:-

$$\frac{LA}{W} = \text{anti-log } (\log A - \log W) \ ... \ (4)$$

Finally, the progress curv̲es for Unit Leaf Rate are obtained from dividing equation (3) by equation (4):-

$$d\,\frac{(\log\ W)}{dT} = \frac{1}{W} \cdot \frac{dW}{dT} \times \frac{1}{\text{anti-log } (\log A - \log W)}$$

Interpretation of the results is aided by comparing the observed values with fitted values and by using an estimation of the standard error for all the fitted values, and to calculate the standard error (S.E.) integration would be necessary as in the related method of Vernon and Allison (1963).

Confidence limits in this calculation could be obtained by multiplying the S.E. of the fitted values by the two-sided 5% significance level of student's distribution, which is based on n-4 degrees of freedom (for the cubic), that is $t(n-4)^{0.05}$. They are limits such that if they were calculated for each of an indefinitely long series of identical experiments, they would include the point of the 'true' curve at that time on a 5%

observations increases, the S.E. will decrease and the value of $t(n-4)^{0.05}$ will decrease towards its limiting value of 1.96, thus narrowing the confidence limits. The confidence limits for L.A.R. are obtained by taking anti-logs of the corresponding confidence limits for Log A - Log W (after allowing for the co-variance of W and A at each time), and hence are slightly asymmetrical about the fitted value.

The programme which suits calculation is written in Algol using Elliot input/output procedures primarily for the 8D3 and 4130 machines, and it has been translated into Fortran to suit the Durham Computer.

The data for the computation are:-

t_1 tn = Times of harvesting

W_1 Wn = Dry weights of plants harvested

a_1 an = Leaf areas of plants harvested

N = Number of plants harvested

M = Number of sets of data to be analysed

T = Significance level of students (t) based on n-4 degrees of freedom

All this data repeated M times.

The computer converts or calculates the natural logarithmns of the dry weights and leaf areas and sorts the harvesting times into ascending order.

The final computer printout reads:-

(1) fitted curves for Log Dry Weights and the S.E.

(2) fitted curves for Log Leaf areas and the S.E.

(3) Constant terms and of Linear, Quadratic and Cubic coefficients, partition of variance, and co-variance into linear, quadratic, cubic, between samples residual and within sample components.

(4) For each harvesting time, the fitted value of Relative Growth Rate (R.G.R.) and its S.E.

(5) For each harvesting time, the fitted values of Leaf Area Ratio (L.A.R.) and its S.E.

(6) For each harvesting time, the observed values of L.A.R. and the fitted values of L.A.R. and its S.E. asymmetric confidence limits.

(7) For each harvesting time, the fitted values of Net Assimilation Rate (N.A.R.) and its S.E.

GREENHOUSE EXPERIMENTS

In order to test the methods to be used in the main field experiments, preliminary comparable work was undertaken in pot culture under greenhouse conditions.

Aim of the Work

The aim of the work was to test the method of comparative growth analysis, and at the same time obtain data relating to the differences between:-

(1) the seeds derived from the three farm systems at Haughley;

(2) the germination and ecesis of the seeds grown under standard conditions;

(3) the effect of various soil types on the germination and ecesis of the seeds.

To this end, the following experiments were carried out in pot culture in an improvised growth cabinet (see Appendix).

EXPERIMENTS 1 and 2

Aim. To compare the dry and imbibed weights of the three types of seed (Organic, Mixed and Stockless).

Method. 200 seeds of each type were selected at random from store at Haughley. 100 of each were dried to constant weight at 80°C, being stored in a dessicator prior to weighing. The other 100 of each type were soaked in distilled water for 24 hours, excess water being blotted from their surfaces before weighing.

Results. The results are summarized in Tables 50a to 50f, and the full data are presented in Appendix pages 282 to 287. Analysis of variance of the samples (Table 51) indicated that the dry weights of both the O and M seeds are significantly greater than those of the S seeds. Whereas the imbibed weights of O seeds are significantly greater than those of both the M and S seeds. The differences, all significant at the 5% level, are summarized below:-

Seed Type	Organic		Mixed		Stockless
Dry weight means.	34.88	=	34.92	>	32.40
Imbibed weight means.	67.56	>	59.84	=	59.83
Uptake of water means.	32.68		24.92		27.43

EXPERIMENT 3. Time course of germination.

Aim. To compare the germination of the three types of seed (Organic, Mixed and Stockless) under laboratory conditions.

Method. Random samples of the three seed types (O, M and S) were soaked in distilled water until imbibition was complete. Six replicate samples, each of fifty seeds, of each type were placed on moistened filter paper in petri dishes. The dishes were then placed in the dark at room temperature, being checked for germination at regular intervals. The appearance of the radicle was recorded as successful germination.

Results. The results are recorded in Table 52, and presented in graph form in Fig. 31. From day three onwards, O seeds

Statistical Analysis of Distribution of Dry and Imbibed Weights, including the Significance Test

Seed type	Dry Weight $\bar{X} \pm$ S.E	σ	σ^2	$\hat{\sigma}$
O	34.88 ± 0.82	8.16	66.60	8.20
M	34.92 ± 0.57	5.70	61.21	5.73
S	32.40 ± 0.50	4.96	24.61	4.99

Seed type	Imbibed Weight $\bar{X} \pm$ S.E	σ	σ^2	$\hat{\sigma}$
O	67.56 ± 0.57	5.70	32.51	5.73
M	59.84 ± 1.07	10.72	114.88	10.77
S	59.83 ± 0.82	8.72	67.93	8.28

Significance test

Seed type	Dry Weight t	d.f	P	R
O - M	0.040	198	1.96	N.S
O - S	2.595	198	1.96	*
M - S	3.334	198	1.96	*

Seed type	Imbibed Weight t	d.f	P	R
O - M	6.359	198	1.98	*
O - S	7.715	198	1.98	*
M - S	0.007	198	1.98	N.S

$\bar{X}$ = Sample Mean ± Standard Error
σ = Standard Deviation of sample
$\hat{\sigma}$ = Estimated standard deviation of the population based on (n-1) degrees of freedom
σ^2 = Sample variance
t = Students'S

d.f = Degrees of freedom
P = Probability value
R = Result of significance
* = Significance difference at 5% level
N.S = No " " " "

TABLE 52

Time Course of Germination

Time (days) \ Seed type	Organic seeds		Mixed seeds		Stockless seeds	
	Mean ± S.E	σ	Mean ± S.E		Mean ± S.E	σ
1	18.0 ± 1.9	4.6	17.3 ± 4.7	11.6	20.3 ± 2.99	7.3
2	32.3 ± 2.7	6.5	45.0 ± 5.7	13.9	48.0 ± 3.6	8.7
3	36.0 ± 1.3	3.1	55.3 ± 5.2	12.7	56.7 ± 8.1	19.9
4	36.3 ± 0.96	2.3	63.3 ± 5.2	12.4	68.7 ± 4.7	11.4
5	37.0 ± 1.6	3.95	65.0 ± 5.1	12.7	72.7 ± 2.5	6.2
6	37.0 ± 1.6	3.95	66.7 ± 5.4	13.1	74.3 ± 2.9	7.1
7	36.7 ± 0.9	2.4	67.3 ± 5.2	12.8	76.3 ± 3.6	8.9

σ = Standard deviation
S.E = Standard error

(O, M, S) Barley Seeds (var. 'Rika')

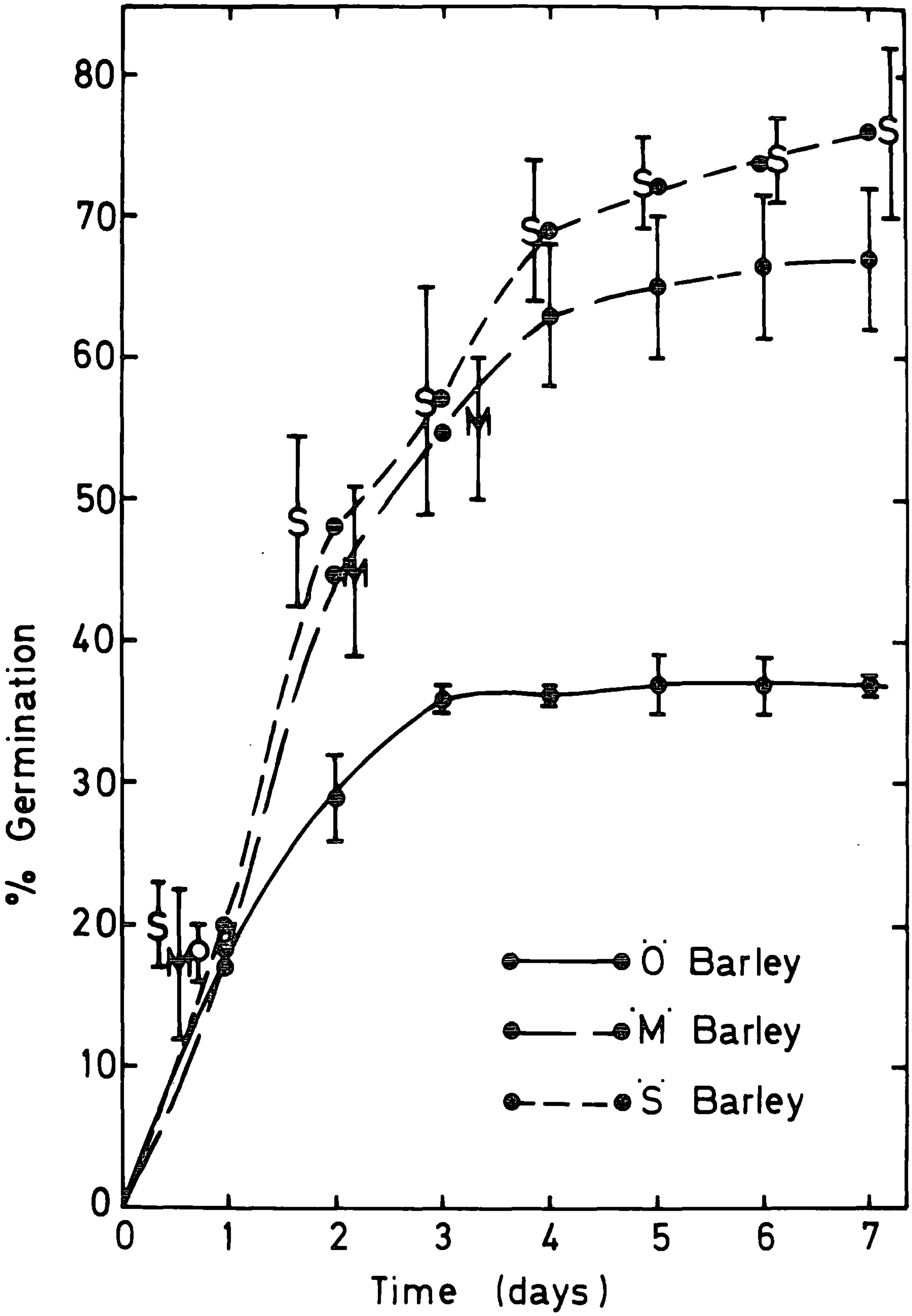


FIG.31 Time Course of Germination.

TABLE 53

Time Course of Germination

Statistical test of significance

Time (days)	Seed type	Significance details t	P	R
1	O - M	0.1257	2.23	N.S
	O - S	0.2539	"	N.S
	M - S	1.1075	"	N.S
2	O - M	4.1109	2.23	*
	O - S	3.9121	"	*
	M - S	2.1121	"	N.S
3	O - M	3.301	2.23	*
	O - S	2.091	"	N.S
	M - S	0.1326	"	N.S
4	O - M	4.787	2.23	*
	O - S	6.230	"	*
	M - S	1.1846	"	N.S
5	O - M	4.775	2.23	*
	O - S	10.861	"	*
	M - S	1.238	"	N.S
6	O - M	4.837	2.23	*
	O - S	10.266	"	*
	M - S	1.145	"	N.S
7	O - M	5.254	2.23	*
	O - S	9.605	"	*
	M - S	1.291	"	N.S

t = Students's
P = Probability value
R = Result of significance
* = Significance difference at 5% level
N.S = No " " " " "

(O, M, S) Barley seeds (var. 'Rika')

showed significantly poorer germination than either M and S seeds (see Table 53).

EXPERIMENT 4. Ecesis.

Aim. To compare the ecesis (measured as seedling performance over the first week of growth) of the three types of seed grown on two types of soil, namely Organic and Stockless.

Method. Samples of the three seed types randomly selected from the store at Haughley, were soaked in distilled water for 48 hours. After imbibition was completed, sub-samples were planted out in pots, filled with either Organic or Stockless soils. The soils had been collected from the top six inches of the appropriate fields at Haughley.

The pots were placed in a latin square arrangement (see Plate 2) in the greenhouse (growth cabinet) at Durham. Plants were harvested at two-day intervals, the length of the plumules and radicles being measured on each occasion.

Results. The results presented in Table 54 and illustrated in graphs in Figs. 32 and 33, allow the following comparisons to be made:-

(1) the performance of the three seed types on each soil;

(2) the performance of each type of seed on the two different soils.

TABLE 54

Measurements of plumules, radicles and total root lengths of all three types of plant grown on two different soils (Organic and Stockless)

Plants grown on Organic soil

Time (days)	Organic plants			Mixed plants			Stockless plants		
	P	R	Total	P	R	Total	P	R	Total
2	0	0.45	3.9	0	0.35	2.9	0	0.42	2.6
4	0.93	5.75	106.30	0.98	6.2	68.5	1.4	5.7	75.5
6	7.4	11.9	148.4	5.6	9.3	134.8	16.5	18.4	206.9
8	15.3	18.9	201.1	16.5	18.4	206.9	17.6	20.6	253.1

Plants grown on Stockless soil

2	0	0.55	3.7	0	0.9	5.3	0	0.4	2.6
4	1.2	5.5	86.7	1.6	6.5	95.4	1.4	7.3	93.1
6	6.7	13.4	149.2	9.1	11.6	156.7	7.6	14.4	175.4
8	17.1	18.9	281.1	17.2	12.1	119.6	15.8	24.4	239.7

P = plumule length
R = radicle "
T = mean total radicle length

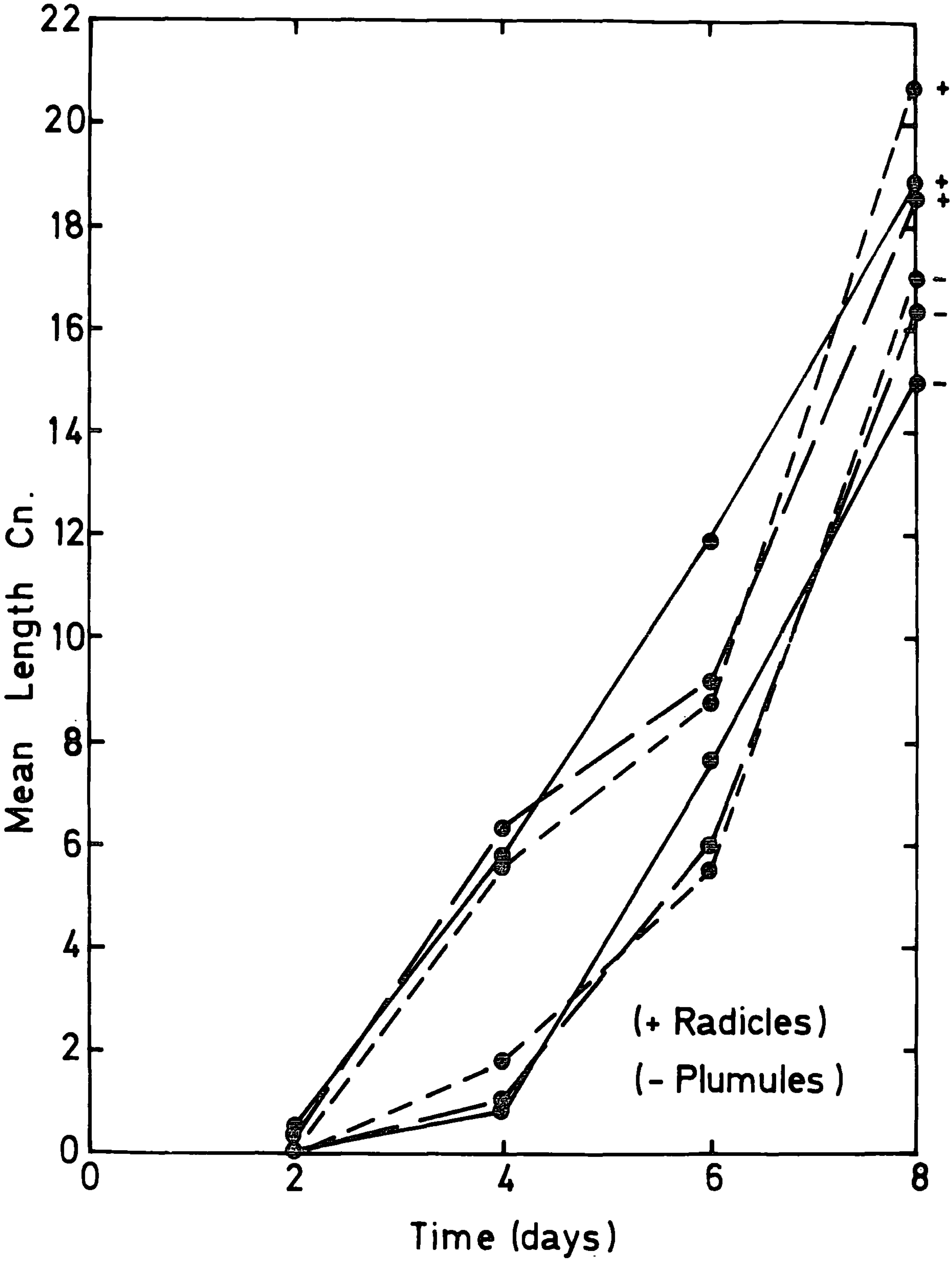


FIG. 32 First week of Germination. (Seeds grown on organic soil.) ●——● 'O' Barley. ●— -● 'M' Barley. ●- - -● 'S' Barley.

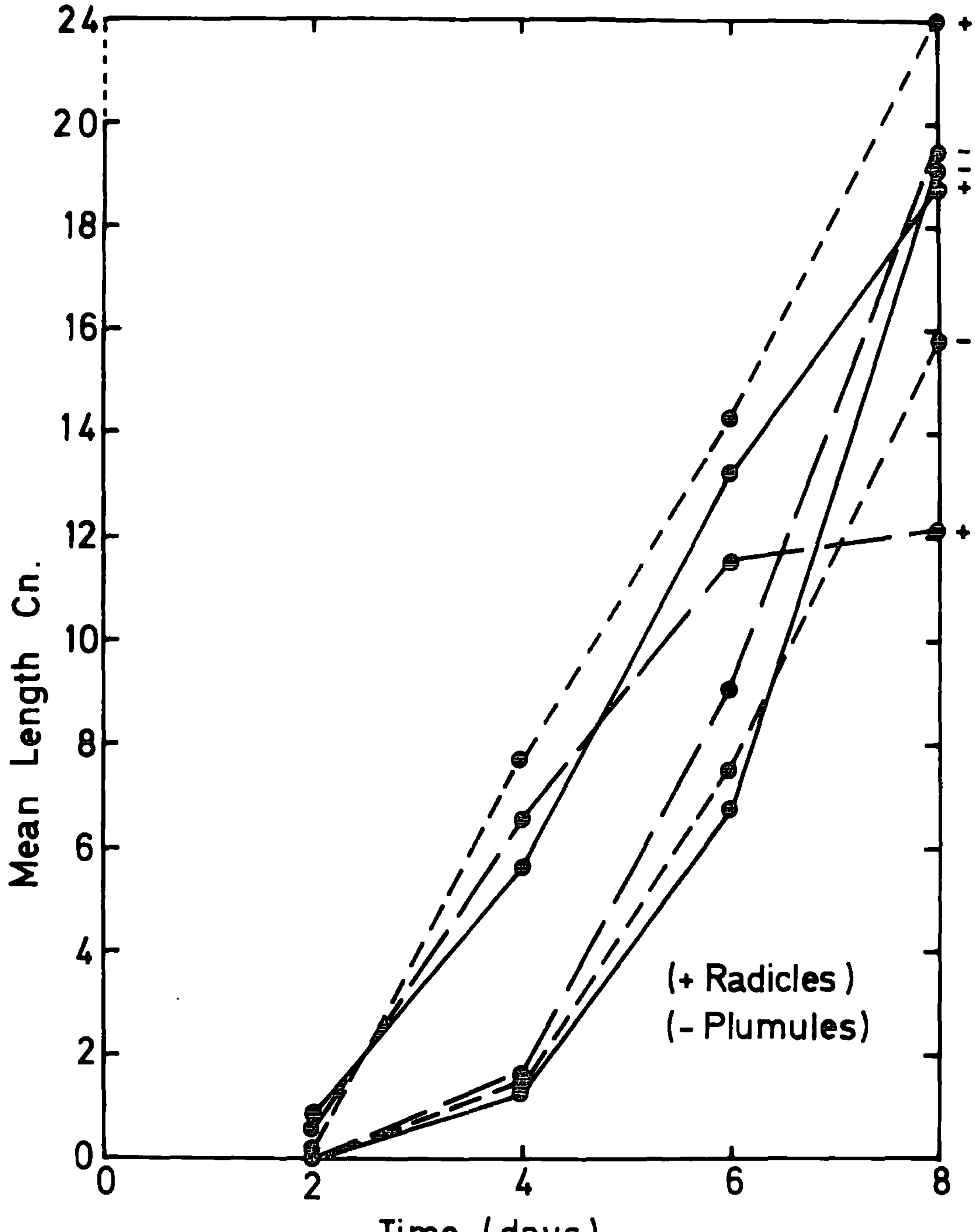


FIG.33 First week of Germination.(Seeds grown on stockless soil) ●——● 'O' Barley ●——● 'M' Barley ●– – –● 'S' Barley seedlings.

Inspection of the graphs and analysis of the results show:-

(1) a more even growth of all the three seed types grown on the Organic soil, compared to their performance on the Stockless soil. In fact, at the termination of the experiment there was no significant difference between either growth function of the plants on the Organic soil.

(2) In contrast, the growth of the seedlings on the Stockless soil was more variable, and at the termination of the experiment the plumules of the Stockless seeds were the same as those of the Organic, which were, themselves, significantly larger than the Mixed.

(3) No significant differences were recorded between the growth of the seedling on the two soils.

<u>EXPERIMENT 5</u>. <u>Preliminary Growth Analysis</u>

<u>Aim</u>. In order to test the methods of growth analysis to be used in the main field experiments, pot experiments set up as above, were continued for a total of 80 days. The results, which appear of interest, are included here to allow preliminary discussion of the growth of the three different types of plants, O, M and S, on the two contrasting soil types, Organic and Stockless.

<u>Method</u>. Small samples of each of three plants were harvested

at regular intervals, and their leaf areas measured prior to the determination of their dry weights. (For details of the method of leaf area and dry weight determinations, see Section V).

Results. The results allow for comparison of the following:-

(1) Dry weight at maximum value.

(2) Leaf area at maximum value.

All the results are shown in Tables 55 and 56 and summarized in Figs. 34 and 35.

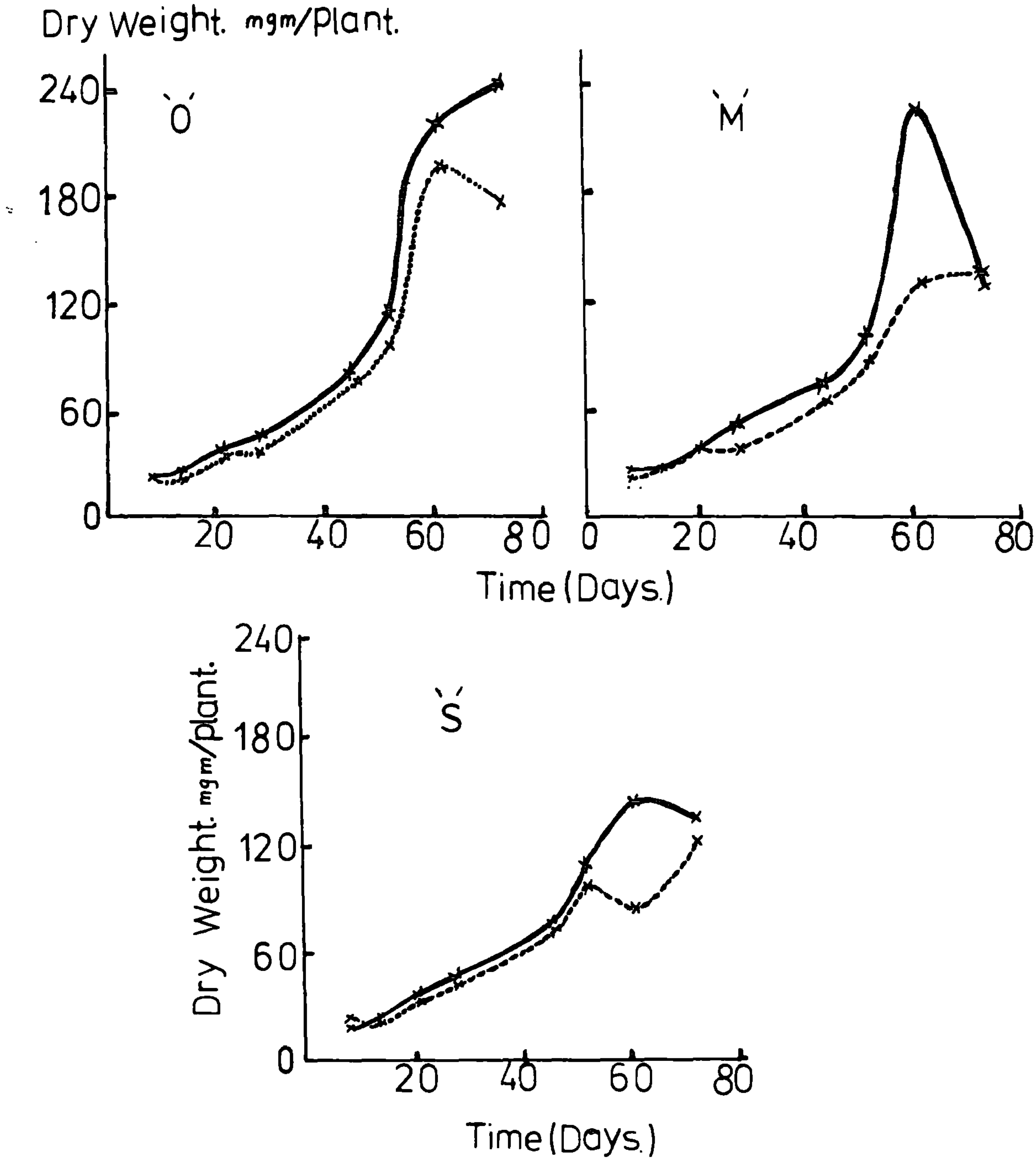
(a) Comparison of the three types of plants growing on the Organic soil

Comparison of the maximum dry weights by analysis of variance (Bailey, 1959), showed significant differences at the 5% level between O and S plants.

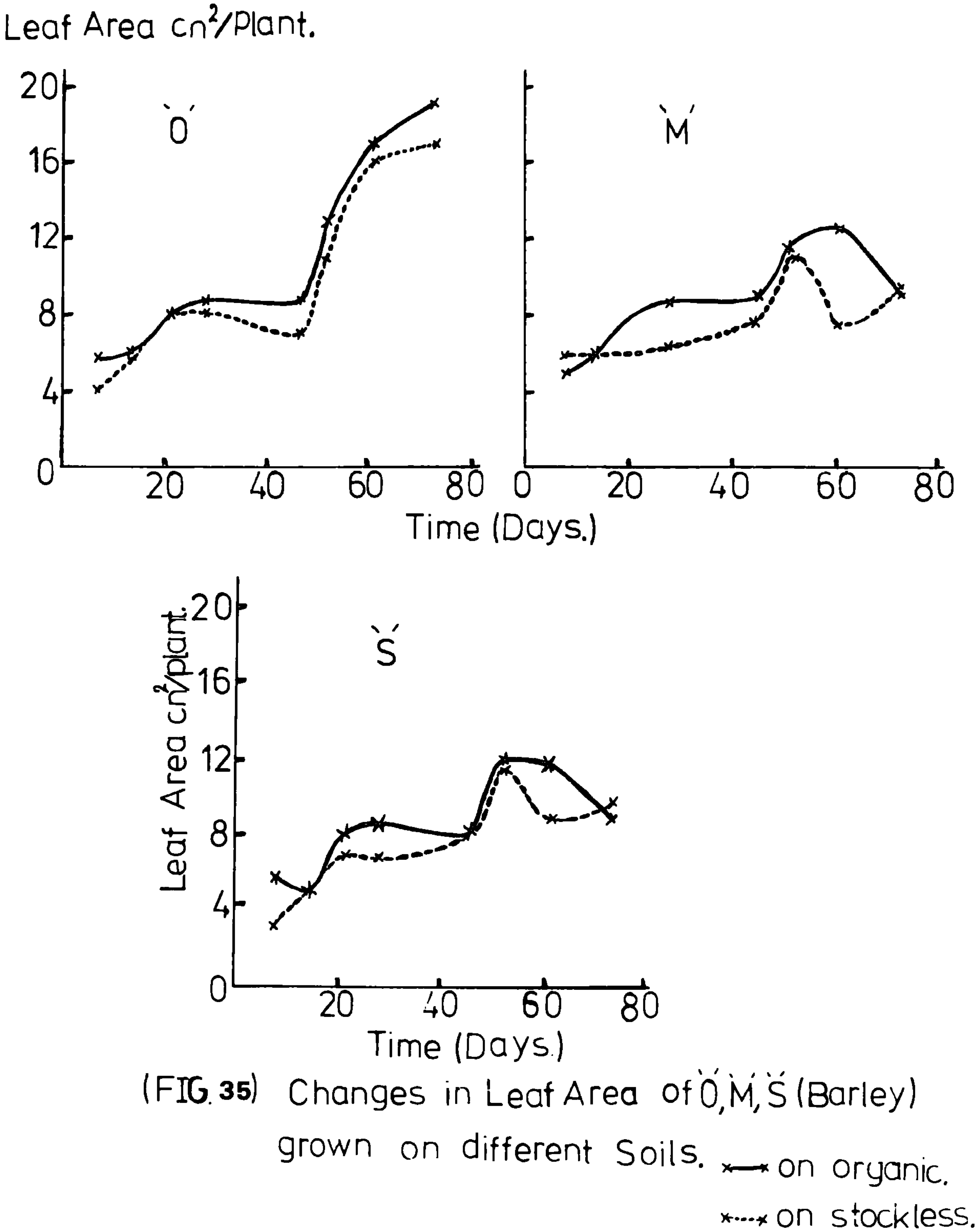
Similar comparisons based on leaf area at maximum showed significant differences between all plant types except M and S plants (see Tables 55 and 56).

(b) Comparison of the three types of plants growing on the Stockless soil

Comparison of the performance based on maximum dry weight showed both the O and S plants to be significantly larger than the M plants. Similar comparison based on maximum leaf area showed the O plants to be significantly larger than both the M and S plants.



(FIG.**34**) Changes in Dry Weight of O, M, S (Barley) grown on different Soils. ×—× on organic. ×---× on stockless.



(FIG. 35) Changes in Leaf Area of O, M, S (Barley) grown on different Soils.

TABLE 55

Mean of the dry weight of the Different Type of Plants grown on Two Types of Soil (Organic and Stockless), at the maximum growth

Plant type \ Soil type	Organic soil	
	Mean ± S.E	St.Dev.
O	241.03 ± 10.5	18.23
M	228.0 ± 1.00	1.73
S	143.57 ± 1.80	31.12
	Stockless soil	
S	199.87 ± C.88	0.879
O	191.62 ± 0.87	1.503
M	133.17 ± 1.60	2.777

Significance test between all types of plants grown on Organic soil

Plant types	F	d.f	P	R
O - M	1.232	2	19.25	N.S
O - S	97.46	4	15.98	*
M - S	4.696	3	9.12	N.S

Significance test between all types of plants grown on Stockless soil

Plant types	F	d.f	P	R
S - O	0.3420	4	2.776	N.S
S - M	9.9701	4	2.776	*
O - M	3.410	4	2.776	*

Test between each type grown on Organic and Stockless soil

Plant type	F	d.f	P	R
O - O	147.100	4	15.98	*
M - M	4.718	4	2.776	*
S - S	3.1307	2	19.25	N.S

All weights in milligrams/plant

O = Organic; M = Mixed; S = Stockless

F = Variance ratio
d.f = Degrees of freedom
P = Probability value
R = Result of significance

* = Significance difference at 5% level
N.S = No " " " " "
S.E = Standard error
St.Dev. = Standard Deviation

Mean of the leaf area of the Different Type of Plants grown on Two Types of Soil (Organic and Stockless), at the maximum growth

Plant type \ Soil type	Organic soil Mean ± S.E	St.Dev.
O	19.033 ± 0.104	0.181
M	11.783 ± 0.704	0.406
S	11.730 ± 0.368	0.638

Significance test between all types of plants grown on Organic soil

Plant types	F	d.f	P	R
O - M	28.253	3	9.12	*
O - S	19.075	3	9.12	*
M - S	0.1214	3	9.12	N.S

	Stockless soil	
O	16.466 ± 0.251	0.435
S	10.930 ± 0.517	0.896
M	10.430 ± 0.296	0.513

Significance test between all types of plants grown on Stockless soil

O - S	9.6266	4	6.39	*
O - M	15.5435	3	9.20	*
S - M	0.8387	4	6.39	N.S

Test between each type grown on Organic and Stockless soil

Plant type	F	d.f	P	R
O - O	9.1368	3	9.12	N.S
M - M	3.8014	4	6.39	N.S
S - S	1.2597	4	6.39	N.S

All areas in Cm^2/plant

(c) Comparison of the performance of each plant type growing on the contrasting soil types

Comparison based on maximum dry weight showed that both the O and M plants grew significantly better on Organic soil. No such differential response was obtained with the Stockless plants. No significant differences in leaf area were recorded (see Table 56).

Discussion

The results of these preliminary experiments, especially bearing in mind the low level of the significance found, can only be taken as an indication of differences between the seeds and soils. The indications are, however, that in the majority of the cases, "organicness", if it can be called such, i.e. organic origin of either the soil or seeds, appears to have a positive result of increasing the performance.

This is in itself remarkable, when it is taken into account that the germination experiment showed exactly the reverse. In fact, germination success of O seeds was only 50% that of the M and S seeds.

Enquiry into the history of the seed stock showed that the Organic seeds had been in the store for one year longer than the other two types, a fact that could easily account for the differential germination. This fact was subsequently proved by comparison with younger stock.

The experience gained in the preliminary experiment was incorporated into the design of the main field experiments, and further discussion will be saved until these have been described in detail.

FIELD EXPERIMENTS

Aim of the Work

(1) To compare the performance of four types of barley:-

3 strains (i.e. seeds from three distinct crops) of variety 'RIKA':-

Organic (O) = Seed from plants grown in Organic field;

Mixed (M) = Seed from plants grown in Mixed field;

Stockless (S) = Seed from plants grown in Stockless field.

*1 strain of variety 'SULTAN' (obtained commercially).

These will be referred to in the text as:- Organic or O plants or O seeds; Mixed or M plants or M seeds; Stockless or S plants or S seeds; Sultan or Su plants or Su seeds. All these seeds were grown on two extreme types of soils (Organic and Stockless) (see Plate 3), thus allowing comparisons of the two extreme farming systems.

(2) To compare the effects of three levels of the addition of fertilizers on the Stockless soil:- (i) Normal soil was

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*At this stage in the experimental work, Haughley Research Farm decided to terminate their experiments on the 'RIKA' barley, replacing it with a modern commercial variety 'SULTAN', that was claimed to give higher production. It was, therefore, decided to test the new variety alongside the others in this work, using it as a single phytometer to compare the systems.

fertilized in 1971; (ii) 3 cwt. N.P.K./acre; and (iii) 5 cwt./acre N.P.K.

To this end two large plots were selected, one in the Organic field, the other in the Stockless field. Sub-plots each 4 x 4 metres were marked out, each separated by a path 2 feet wide; the various experiments were laid out in Latin square as shown in Figs. 38 and 38a. The seeds were sown and the requisite fertilizers were added by hand, two weeks after germination was completed.

Sampling. Samples, each consisting of three plants picked at random from each treatment, were harvested at two weekly intervals. The plants were carefully removed, loosely adhering soil being shaken from the roots. After transportation to the laboratories the root systems were washed thoroughly, first in tap and then distilled water. Leaf area was measured and dry weight calculated.

The plants were then ground to a fine powder, which was used for geochemical analysis. For details see Section V .

Results. It was decided to attempt a preliminary discussion based on the absolute data for dry weights and leaf areas.

Bearing in mind the small size of the samples used, the growth curves are on the whole satisfactory, allowing the following measured comparisons to be made:-

(1) The maximum dry weight per plant.

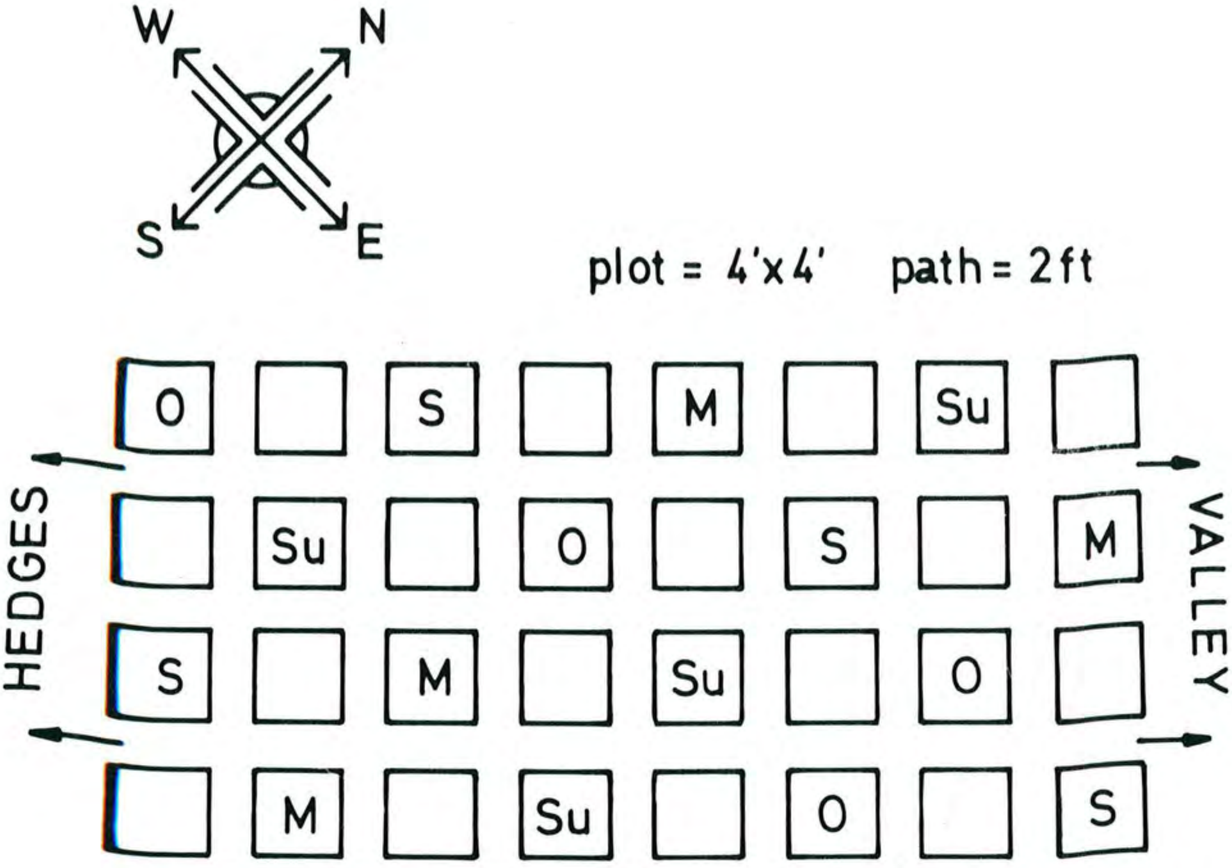
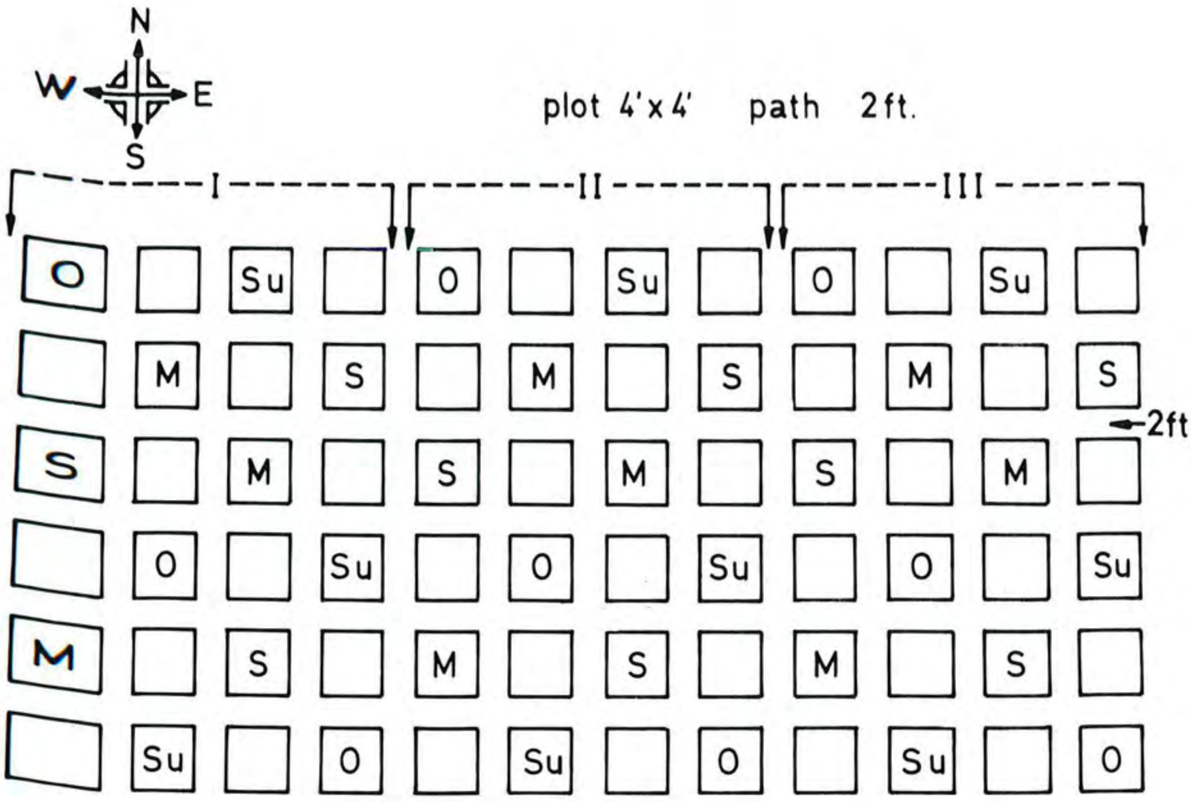


FIG. 38. Latin square arrangements in the Organic field.

O, M, S = Barley (var. RIKA)

Su = Barley (var. SULTAN)



(FIG. 38a) Latin square arrangements in the stockless field.

O,M,S Barley (var.RIKA)
Su " (" SULTAN)

I. No Fertilizer

II. 3 cwt. N.P.K.

III. 5 cwt. N.P.K.

(2) The maximum leaf area per plant.

(3) The time at which these maxima were attained.

(A) Absolute Data

Comparisons based on dry weights:

(1) Comparisons of the four seed types grown on the Organic soil

Results. The results are shown graphically in Fig. 39, and summarized in Table 57. The values of the dry weight at maxima are shown below:-

S	Su	O	M	
3700.4	3231.3	2778.1	2010.2	mg/plant

Sultan and Mixed plants reached their maxima at week 12, then the Organic and the Stockless plants a fortnight later.

Conclusion. The analysis of significance showed that all differences shown between all four seed types are significant (see Table 57).

(2) Comparisons of the four seed types grown on the Stockless soil without fertilizer

Results. The results are shown graphically in Fig. 39 and are tabulated in Table 57. Value of the dry weight at maxima are shown below:-

Su	M	O	S	
3110.7	2352.3	2143.8	1520.7	mg/plant

Sultan was the only variety that gave its maximum dry weight on week 10, followed by the Organic and the Stockless plants at week 12. The Mixed plants showed their maxima on Week 14.

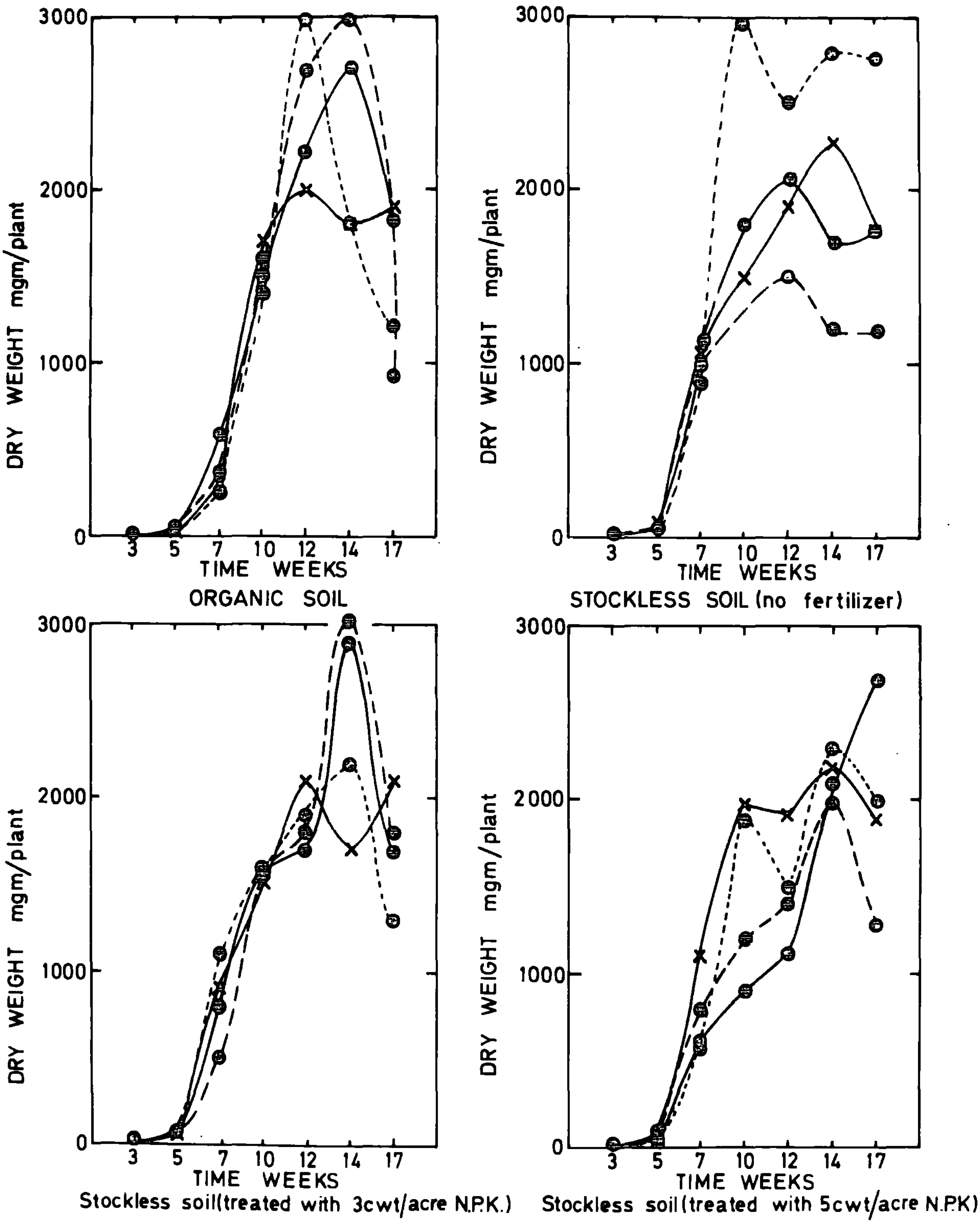


FIG.**39** Changes in dry weights of (O,M,S,Su) Barley grown on different soils.

⊖—⊖ O BARLEY (RIKA) ⊖– –o S BARLEY (RIKA)

×—× M " " ⊖----⊖ Su " (sultan)

TABLE 57

Tables presented are:-

(A) Summary table of the mean of the dry weights of four plant types grown on:-

Soil treatments	Plant Types			
	O	M	S	Su
1. Organic soil	2778.10 ± 0.1	2010.20 ± 0.03	3700.40 ± 1.14	3231.30 ± 1.04
2. Stockless soil without N.P.K.	2143.80 ± 0.9	2352.30 ± 0.5	1520.70 ± 0.7	3110.70 ± 0.1
3. Stockless soil with 3 cwt. N.P.K.	2851.50 ± 0.99	2122.50 ± 0.60	3089.40 ± 0.70	2205.40 ± 0.9
4. Stockless soil with 5 cwt. N.P.K.	2075.80 ± 0.36	2170.70 ± 0.15	2041.80 ± 0.06	2298.30 ± 0.63

(B) Test of significance

Plant type	Organic soil			Stockless soil			Stockless soil + 3 cwt. N.P.K.			Stockless soil + 5 cwt. N.P.K.		
	t	P	R	t	P	R	t	P	R	t	P	R
O - M	24.00	2.775	*	4.166	2.775	*	2.417	2.776	N.S	2.03	2.4	N.S
O - S	360.00	"	*	1.563	"	N.S	1.730	"	N.S	2.10	"	N.S
O - Su	324.00	"	*	56.25	"	*	1.397	"	N.S	2.26	"	N.S
M - S	16.67	"	*	2.256	"	N.S	1.397	"	N.S	2.18	"	N.S
M - Su	13.50	"	*	16.00	"	*	2.315	"	N.S	2.32	"	N.S
S - Su	224.00	"	*	36.00	"	*	1.657	"	N.S	2.35	"	*

t = Students
P = Probability value
R = Result of significance

* = Significance at 5% level
N.S = No significance at 5% level

Conclusion. The results of the analysis of significance are presented in Table 57. The results showed that significant differences exist between:-

Organic	and	Mixed
2143.80		2352.30
Organic	and	Sultan
2143.80		3110.70
Mixed	and	Sultan
2352.30		3110.70

and were not between:-

Organic	and	Stockless
2143.80		1520.70
Mixed	and	Stockless
2352.30		1520.70

(3) Comparisons of the four seed types grown on the Stockless soil with 3 cwt./acre N.P.K.

Results. The results of the dry weights are tabulated in Table 57, and are presented graphically in Fig. 39. The maximum weights have been shown below:-

S	O	Su	M	
3089.4	2851.5	2205.4	2127.5	mg/plant

Conclusion. The results of the significance test, tabulated in Table 57, showed that no significant difference was found between the growth of any of the plants on the Stockless soil treated with 3 cwt./acre N.P.K.

(4) Comparisons of the four seed types grown on the Stockless soil with 5 cwt/acre N.P.K.

Results. The results of the dry weight of the different plant types are summarized in Table 57, and also shown in Figure 39. Dry weights of the plants at their maxima are shown below:

Su	M	O	S	
2298.3	2170.7	2075.8	2041.8	mg/plant

Two peaks for Mixed and Sultan plants were shown between 10 and 14 weeks. The Stockless plants reached their maximum dry weight on week 14. Organic plants did not attain their highest dry weight until week 17.

Conclusion. The analysis of significance is shown in Table 59, and showed that the Sultan plants were significantly heavier than the Stockless.

Comparison of the growth of each type of plant on two different soils (Organic and Stockless), and three different levels of fertilizers on Stockless soils.

Results. The results are summarized in Table 58.

Conclusions. The organic, stockless and Sultan plants showed a significantly better performance on the organic soil than was attained on the stockless soil, the Mixed did not.

At 3 level of fertilizers additions, the organic and stockless soil without fertilizers except Sultan plants which their increases were high on the soil without fertilizers.

At 5 level of N.P.K. The significant differences which showed in Stockless and Sultan plants are higher on the soil without N.P.K. than on soil treated with 5 cwt N.P.K. The

TABLE 58

Comparisons of each Type of Plant between Treatments

(1) Dry Weight at maximum

Plant type	Organic v. Stockless			Stockless v. Stockless with 3 cwt. N.P.K.			Stockless v. Stockless with 5 cwt. N.P.K.		
	t	P	R	t	P	R	t	P	R
O	164.28	9.12	*	9.2608	9.12	*	57.50	9.12	N.S.
M	2.666	"	N.S	1.891	"	N.S	0.143	"	N.S
S	144.00	"	*	11.174	"	*	149.00	"	*
Su	81.00	"	*	30.25	"	*	30.25	"	*

(2) Leaf Area at maximum

Plant type	Organic v. Stockless			Stockless v. Stockless with 3 cwt. N.P.K.			Stockless v. Stockless with 5 cwt. N.P.K.		
	t	P	R	t	P	R	t	P	R
O	34.00	19.25	*	3.587	2.776	*	2.66	2.776	*
M	251.0	"	*	24.19	19.25	*	16.44	6.25	*
S	112.5	9.28	*	2.00	2.776	N.S	3.478	2.776	*
Su	1.60	2.77	N.S	3.66	2.776	*	196.23	9.12	*

t = Students'S
P = Probability value.
R = Result of significance.

* = Significance at 5% level.
N.S = No significance at 5% level.

summary table showing the differences is presented below:

Soil treatments	Plant type O	M	S	Su	
Organic Soil	2778	2010	2700	2231	mg/plant
Stockless with no fertilizers	2143	2352	2520	3100	mg/plant
Stockless with 3 cwt/ acre N.P.K.	2851	2122	3084	2205	mg/plant
Stockless with 5 cwt/ acre N.P.K.	2075	2170	2041	2298	mg/plant

Conclusions from absolute dry weight comparisons

No pattern emerged when comparing plant types on the different soil and soil treatments, ruling out, at least in part, the development of dependence of the seed types on the soil types on which it was normally grown. In fact, Stockless plants showed their maximum dry weight on Organic soil and, in contrast, their lowest maximum on the Stockless soil.

In contrast, comparison between soils showed that in all cases, except that of the Mixed seeds, performance was better on the Organic soil. The lack of any set pattern of growth responses obtained at the two levels of fertilizer applications point to the fact that both farm systems probably provide the crops with sufficient nutrients for this normal growth.

Comparison based on Leaf area

(1) Comparision of the four seed types grown on the Organic soil

Results. The results of the leaf area for all different plant types are shown in Table 59, and also presented in Fig. 40. Data for area at maxima are shown below:-

M	S	O	Su	
137.5	124.7	95.8	76.4	cn^2/plant

Organic, Stockless and Sultan plants reached their maxima of leaf areas on week 10. On the other hand, Mixed gave their maxima a fortnight later (week 12).

Conclusions. The analysis of significance tabulated in Table 59, showed that all gave significant differences, except those between Mixed and Stockless plants.

(2) Comparison of the four types of seeds growing on the Stockless soil without fertilizer

Leaf Area.

Results. All results of leaf area for the different plant types are shown in Table 59, and also illustrated in Fig. 40. Data for leaf area at maximum values are shown below:-

M	O	Su	S	
87.8	78.8	71.3	66.2	cn^2/plant

All plants reached their maxima on week 7. Mixed and Sultan however, then regressed and showed a second maximum on week 12.

Conclusions. The significance test has been carried out between the means of the leaf area of the four types. The results are presented in Table 59, and showed

TABLE 59

Tables Presented are:-

(A) Summary table of the mean leaf area of four plant types grown on:-

Soil treatment	Plant type			
	O	M	S	Su
1. Organic soil	95.80 ± 0.06	137.50 ± 0.17	124.7 ± 0.20	76.40 ± 0.18
2. Stockless soil without fertilizers	78.80 ± 0.45	87.80 ± 0.19	66.20 ± 0.47	71.30 ± 0.113
3. Stockless soil with 3 cwt. N.P.K.	93.70 ± 0.13	95.20 ± 0.243	76.40 ± 0.144	103.30 ± 0.414
4. Stockless soil with 5 cwt. N.P.K.	137.4 ± 0.152	105.70 ± 0.38	98.50 ± 0.131	93.30 ± 0.06

(B) Test of significance

Plant type	Organic Soil					Stockless soil without N.P.K.					Stockless soil with 3 cwt. N.P.K.					Stockless soil with 5 cwt. N.P.K.				
	F	f_1	f_2	P	R	F	f_1	f_2	P	R	F	f_1	f_2	P	R	F	f_1	f_2	P	R
O - M	208.5	4	2	19.25	*	18.00	4	2	19.25	N.S	5.00	4	3	9.12	N.S	72.05	4	3	9.12	*
O - S	121.4	4	2	19.25	*	18.00	4	4	6.39	*	72.08	4	3	9.12	*	176.8	4	4	6.36	*
O - Su	97.00	4	2	19.25	*	15.00	4	2	19.25	N.S	19.2	4	2	19.25	*	220.0	4	3	9.12	*
M - S	44.75	4	1	224.6	N.S	43.24	4	3	9.12	*	58.75	4	4	6.39	*	18.00	4	2	19.25	N.S
M - Su	189.38	4	3	9.12	*	72.07	4	3	9.12	*	16.20	4	2	19.25	N.S	31.00	4	2	19.25	*
S - Su	163.18	4	4	6.39	*	10.20	4	2	19.25	N.S	53.80	4	3	9.12	*	28.90	4	2	19.25	*

F = Variance ratio; f_1, f_2 = degrees of freedom (see Bailey, 1959)
P = Probability value
R = Result of significance
* = Significance at 5% level
N.S = No significance at 5% level

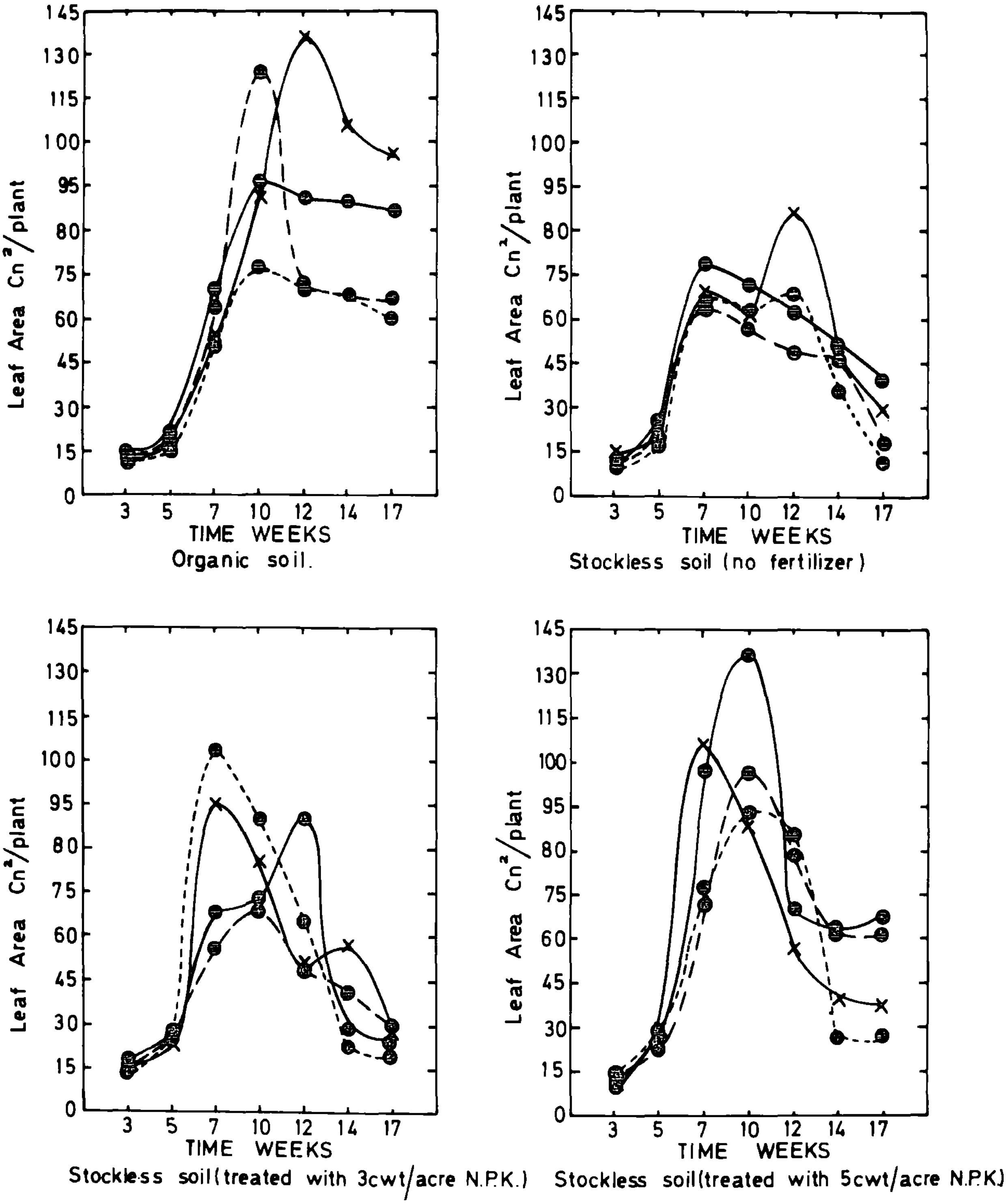


FIG.**40** Changes in Leaf Area of (O,M,S,Su) Barley grown on different soils

O BARLEY (RIKA) — S BARLEY (RIKA)

M " " — Su " (sultan)

that the differences are significant between the Mixed plants and Sultan and Stockless plants. Also, between the Organic and Stockless plants.

(3) <u>Comparison of the four types of seeds growing on the Stockless soil with 3 cwt./acre N.P.K.</u>

Results. Table 59 shows the results of the leaf area throughout the growing season, and also the data are presented graphically in Fig. 40. Data for area at maxima are shown below:-

Su	M	O	S	
103.3	95.2	93.7	76.4	cn^2/plant

Sultan and Mixed plants gave their maximum levels of leaf area at week 7. After that, on week 10 the Stockless plants showed their peak of leaf area. The Organic plants were the only ones that reached their highest area on week 12.

Conclusion. The differences in area are tested statistically and the results are shown in Table 59. The significant differences are shown between:-

(1) Sultan and that of the Organic and Stockless plants.

(2) Stockless and that of both Mixed and Organic plants.

(4) <u>Comparison of the four types of seeds growing on the Stockless soil with 5 cwt./acre N.P.K.</u>

<u>Leaf area.</u>

Results. The results are tabulated in Table 59 and shown in Fig. 40. Data for leaf area at maxima are shown below:-

O	M	S	Su	
137.4	105.7	98.5	93.3	cn^2/plant

Mixed plants were the only plants that gave their maximum area on week 7, then afterwards all the rest of the plants reached their maxima of area on week 10. Highest area was shown by the Organic plants.

Conclusion. The results of the significance test are shown in Table 59. In all plant types the differences between the means of their leaf areas are significant, except the Mixed and Stockless plants.

Comparison of the Growth of each type of plant on two different soils (Organic and Mixed), and three different levels of fertilizers on the Stockless soil

Results. The results are summarized in Table 58 .

Conclusions. Mixed, Stockless and Organic plants showed significantly better performance on the Organic soil than they attained on the Stockless soil. Sultan did not.

The performance of all plant types, except Stockless, on soil treated with 3 cwt./acre N.P.K. fertilizers, showed significant increase compared with that on untreated Stockless soil. Also, the increases are significant in all plant types grown on the Stockless soil treated with 5 cwt./acre N.P.K. fertilizers (see Summary Table below):-

Soil treatment	Plant types O	M	S	Su
Organic soil	95.8	137.5	124.7	76.4
Stockless soil - no fertilizers	78.8	87.8	66.2	93.2
Stockless soil with 3 cwt./acre N.P.K.	93.7	95.2	76.4	103.3
Stockless soil with 5 cwt./acre N.P.K.	137.4	105.7	98.5	71.3

Conclusions from Absolute Leaf Area Comparison

When comparing plant types on different soil and soil treatments, in all cases plants grown on Organic soil performed better than when they were grown on other soil treatments, except in the case of the Organic plants which performed better on Stockless soil treated with 5 cwt./acre N.P.K. fertilizers, and Sultan plants when grown on the Stockless soil with 3 cwt./acre N.P.K. fertilizers.

(B) Computer Analysis of the Growth Data

The Hughes and Freeman (1967) programme was modified for use on the Durham IBM 360 and IBM 1130 computers. The programme as used, converted the absolute values to log weights and log leaf areas and calculated figures for the Relative Growth Rate, Leaf Area Ratio and Net Assimilation Rate. The programme also computed standard errors where relevant, and fitted curves to the output data. All the fitted curves are shown in Figs. 41 to 44 and 44 (1-12) found in Appendix pages 300 to 311

<u>Interpretation</u>. In all cases:-

(1) Log dry weight rose to a maximum at about 98 days.

(2) Net Assimilation Rate found its maximum value between 49 and 70 days, except in the case of O barley growing on Stockless soil with 5 cwt./acre N.P.K. fertilizer, which reached its peak value only at the termination of the experiment.

(3) Both Relative Growth Rate and Leaf Area Ratio fell steadily throughout the growing season from its highest recorded value at 21 days.

The overall similarity of the curves indicated that there was no significant differences between any of the seeds on any of the treatments.

Analysis of fitted curves by the computer produced linear, quadratic and cubic regressions (see Tables 60-60c)/ see Appendix pages 288-291, and the analysis of variance based on these regressions showed no significant differences.

Following the example of Hughes and Freeman (1967), totals were computed for the variance when certain significant differences emerged, but only at the 20% significance level. These are summarised in Table 61 to 61c. see Appendix pages 292-295

(a) <u>Comparison on Organic soil</u>

<u>Dry Weight</u>: Only significant differences are shown

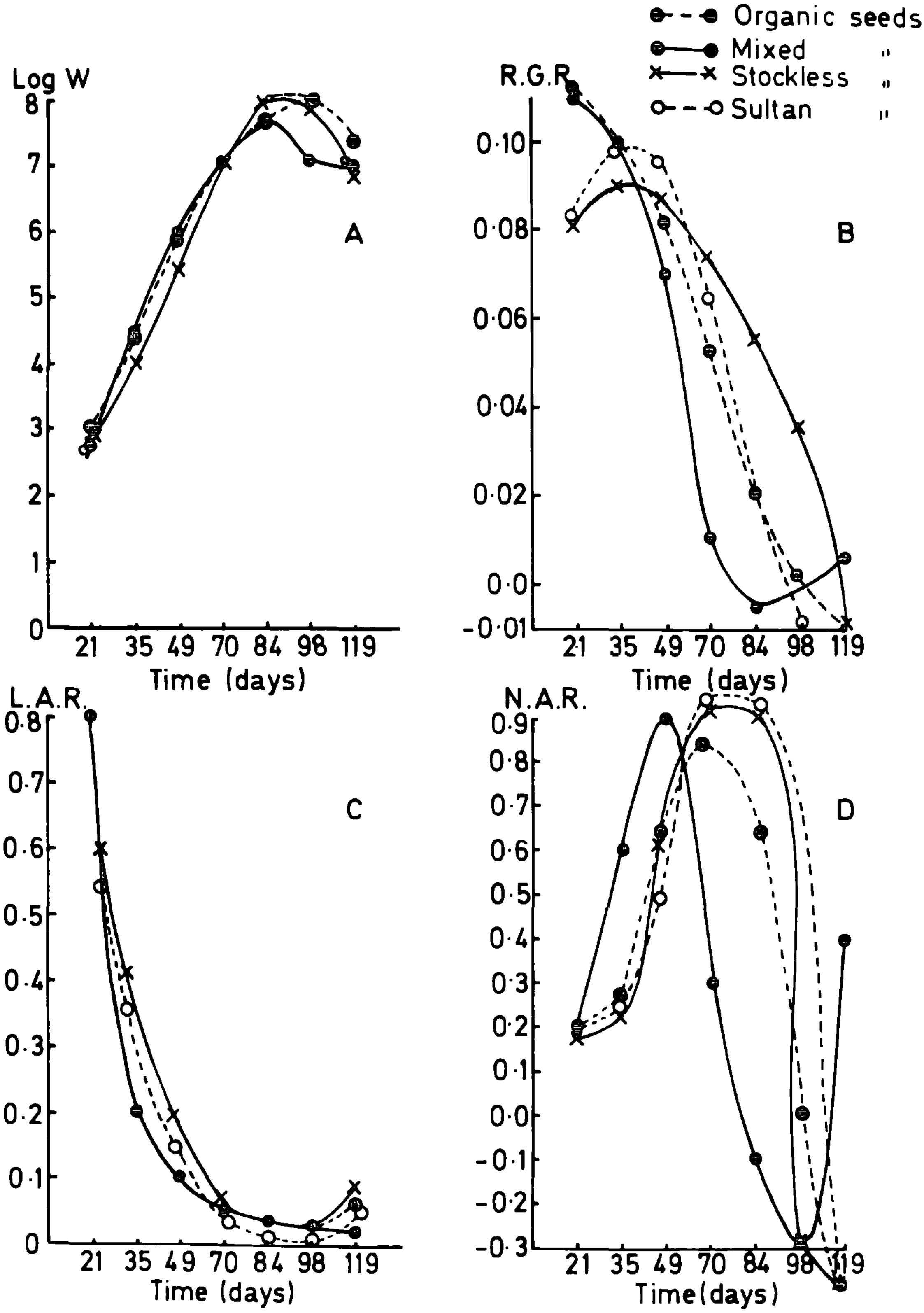


FIG.**41** Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. All seed types grown on Organic field. (Lower Wassicks)

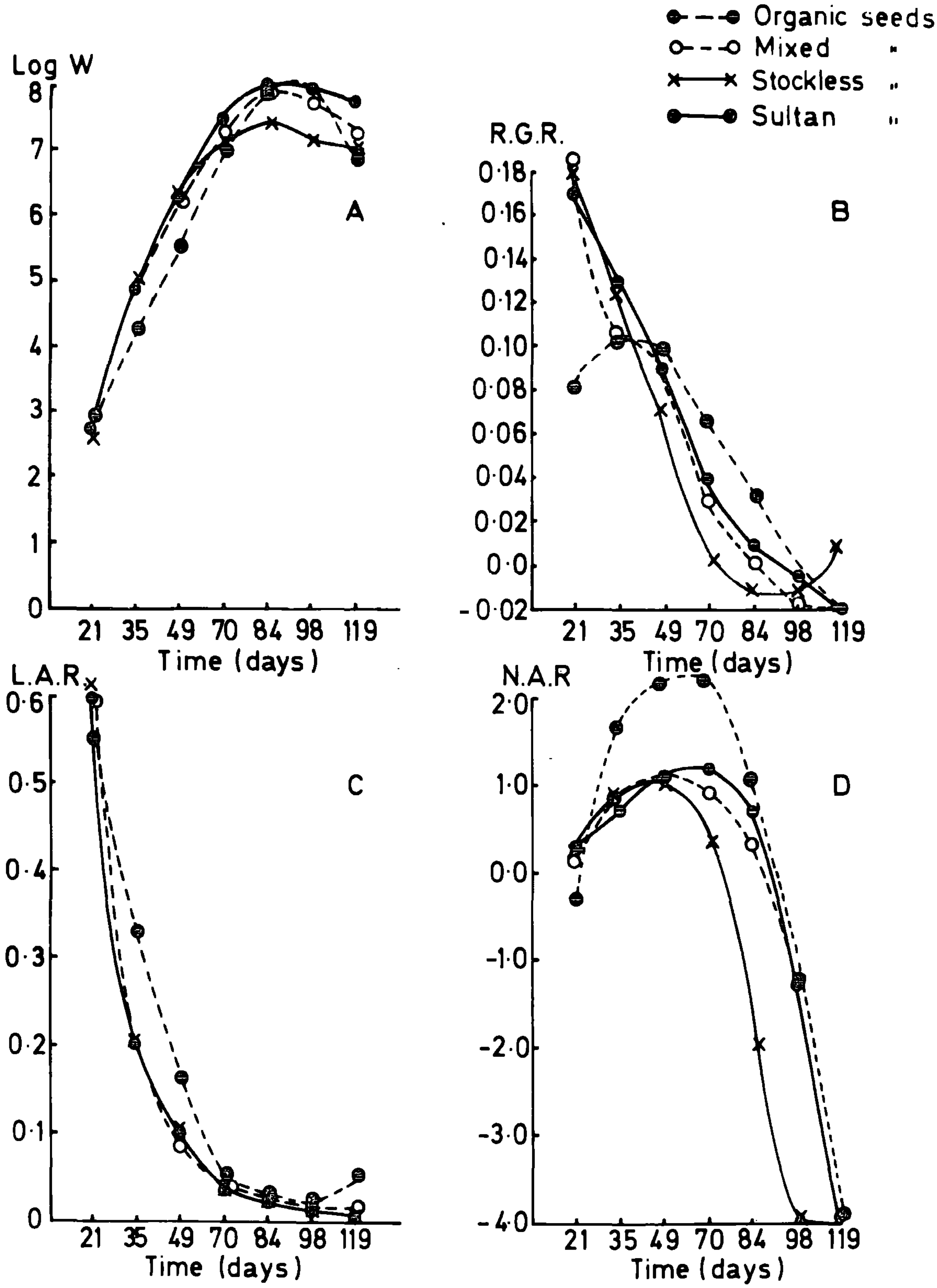


FIG. **42** Progress Curves of (A) Log Dry Weight. (B) R.G.R Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. All seed types grown on stockless field. (Road Field)

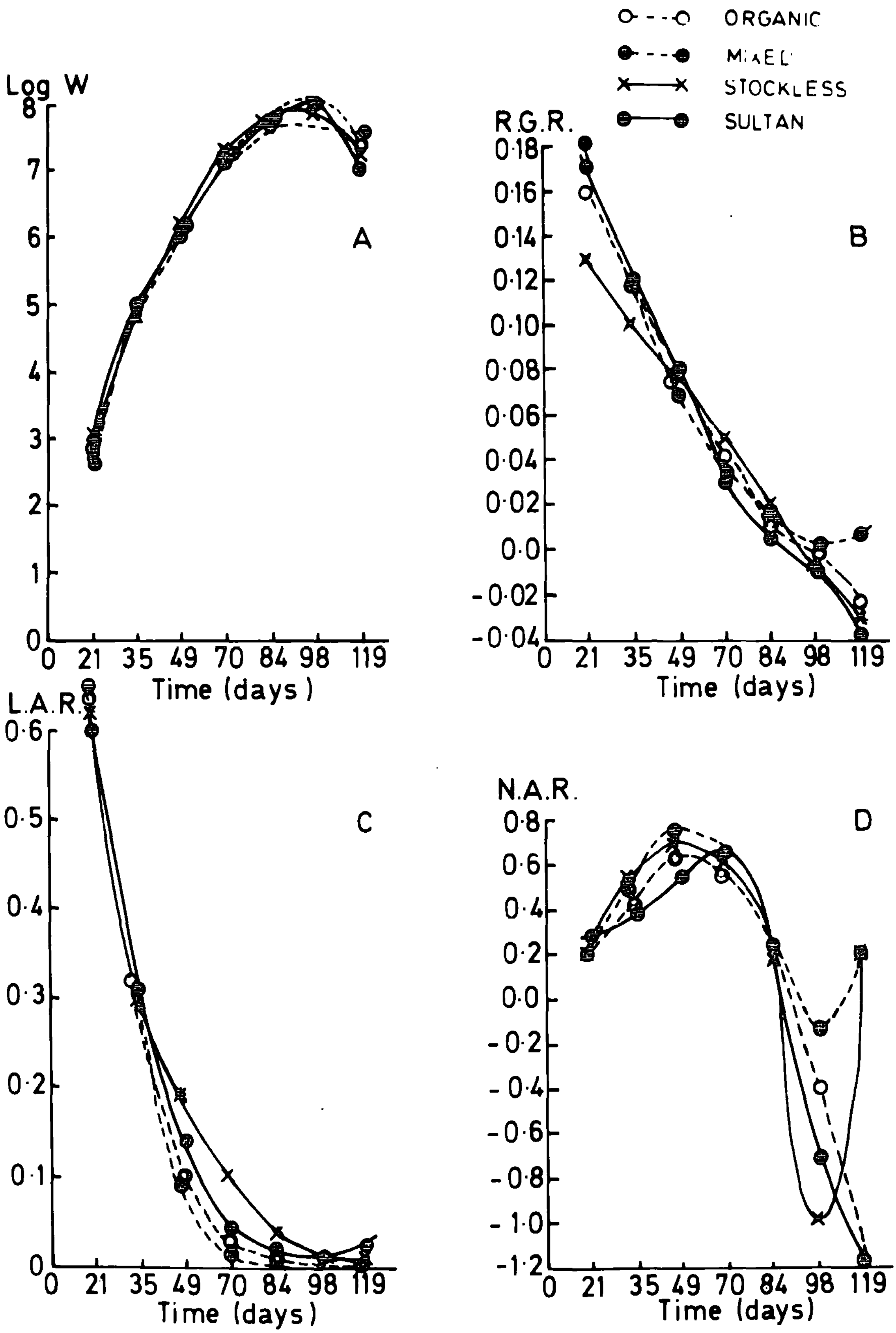


FIG. **43** Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. All seed types grown on Stockless soil treated with 3cwt/acre N.P.K.

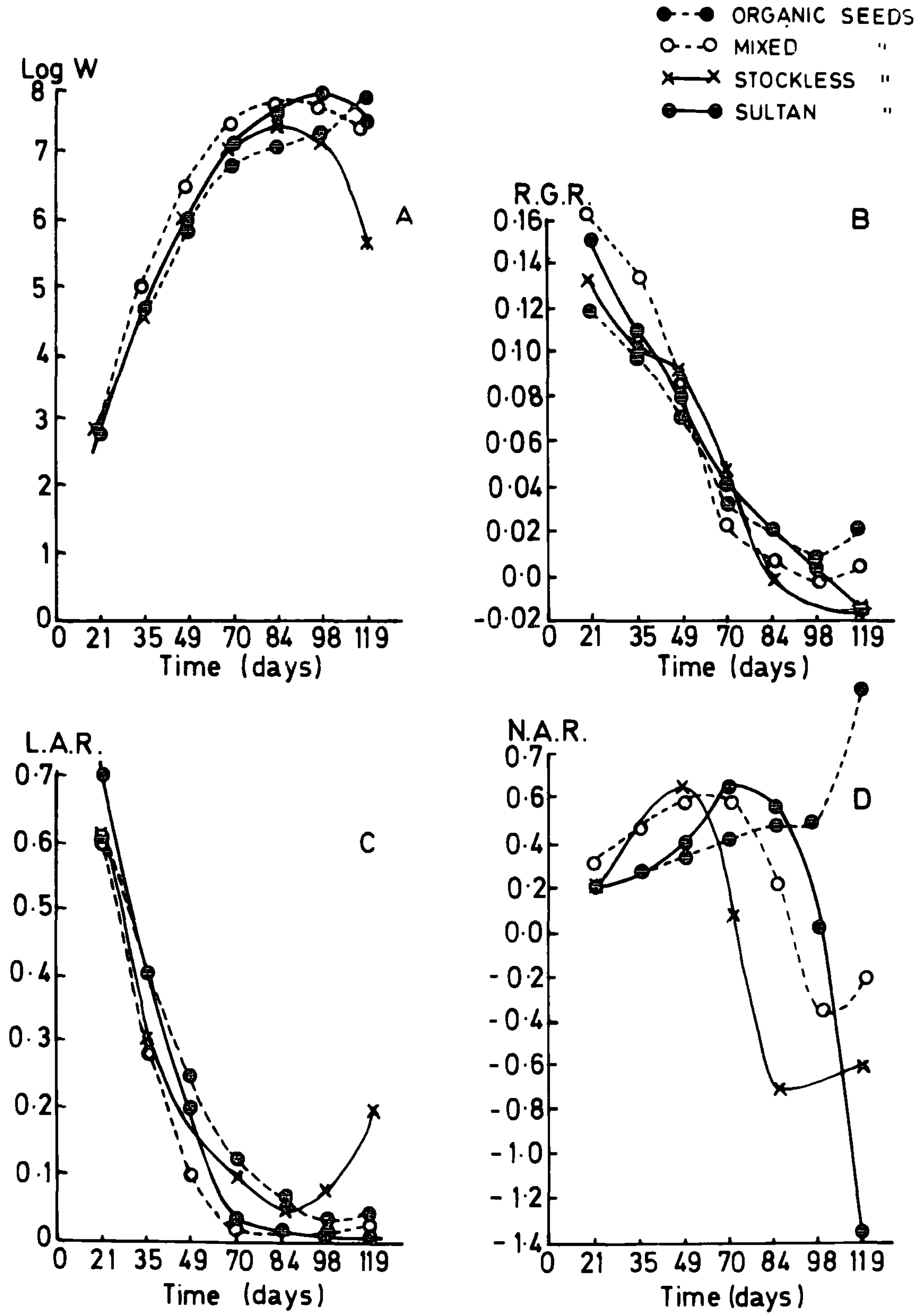


FIG.44 Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. All seed types grown on Stockless soil treated with 5cwt/acre N.P.K.

between:-

$O < M$

$O < Su$

<u>Leaf Area</u>: No significant differences between leaf areas.

(b) <u>Comparison on Stockless soil</u>

<u>Dry Weight</u>: Significant differences are found between:-

$O > Su$

$M < S$

$S > Su$

<u>Leaf Area</u>: The only significant differences are found between:-

$M < Su$

$S < Su$

(c) <u>Comparison on Stockless soil with 3 cwt. N.P.K. fertilizer</u>

No significant differences are found either in the dry weight or leaf area.

(d) <u>Comparison on Stockless soil with 5 cwt.N.P.K. fertilizer</u>

<u>Dry Weight</u>: No significant differences are found.

<u>Leaf Area</u>: The only significant differences are shown between:-

$M > Su$

$S < Su$

(e) <u>Comparison of Plant types between treatments</u>

(1) Organic vs. Stockless

Dry weight (See Table 62)

The significant differences are found only between:

M on Organic soil > M on Stockless soil

Su on Organic Soil > Su on Stockless soil

(2) Stockless soil vs. Stockless with 3 cwt. N.P.K.

There are no significant differences found between plant types.

(3) Stockless soil vs. Stockless with 5 cwt. N. P.K.

Also, there are no significant differences obtained between plant types.

Leaf Area:

(1) Organic vs. Stockless

The only significant difference was found between:

Su on Organic soil > Su on Stockless soil

(2) Stockless soil vs. Stockless with 3 cwt. N.P.K.

No significant differences are found.

(3) Stockless soil vs. stockless with 5 cwt. N.P.K.

No significant differences are obtained. For details see Table 63.

Overall Conclusions

The overall similarity of the fitted curves for all the growth functions computed and the very few and very low levels of significance recorded between seed and treatments, can only lead to the conclusions that:

(1) there is no significant effect of the soils on

TABLE 62

Plant Growth Curves

Comparisons of dry weights of each type of plant between treatments

Between one type of plant growing on Organic soil with the same plant on Stockless soil

Plant type \ Regression Equation	Linear				Quadratic				Cubic				Total			
	F	P		R	F	P		R	F	P		R	F	P		R
		20%	5%			20%	5%			20%	5%			20%	5%	
O - O	1.054	9.5	161.5	N.S	1.353	9.5	161.5	N.S	1.44	9.5	161.5	N.S	1.529	2.1	4.3	N.S
M - M	1.23	"	"	N.S	1.001	"	"	N.S	2.36	"	"	N.S	2.11	"	"	**
S - S	1.44	"	"	N.S	2.365	"	"	N.S	1.001	"	"	N.S	1.483	"	"	N.S
Su - Su	1.059	"	"	N.S	3.235	"	"	N.S	5.363	"	"	N.S	2.252	"	"	**

Between each type of plant growing on Stockless soil without N.P.K. and the same on Stockless soil + 3 cwt. N.P.K.

O - O	1.226	9.5	161.5	N.S	1.275	9.5	161.5	N.S	3.75	9.5	161.5	N.S	1.662	2.1	4.3	N.S
M - M	1.091	"	"	N.S	1.124	"	"	N.S	1.291	"	"	N.S	1.751	"	"	N.S
S - S	4.909	"	"	N.S	4.76	"	"	N.S	1.289	"	"	N.S	1.379	"	"	N.S
Su - Su	1.448	"	"	N.S	1.309	"	"	N.S	1.082	"	"	N.S	1.721	"	"	N.S

Between each type of plant growing on Stockless s il without N.P.K. and the same on Stockless soil + 5 cwt. N.P.K.

O - O	1.023	9.5	161.5	N.S	2.815	9.5	161.5	N.S	2.370	9.5	161.5	N.S	1.374	2.1	4.3	N.S
M - M	1.035	"	"	N.S	1.028	"	"	N.S	1.192	"	"	N.S	1.069	"	"	N.S
S - S	5.827	"	"	N.S	1.588	"	"	N.S	1.519	"	"	N.S	1.010	"	"	N.S
Su - Su	1.063	"	"	N.S	1.035	"	"	N.S	1.102	"	"	N.S	1.138	"	"	N.S

F = Variance ratio
P = Probability value
R = Result of significance

* * = Significance at 20% level
N.S = No significance at either 5% or 20% level

TABLE 63

Plant Growth Curves

Comparisons of leaf areas of each type of plant between treatments

Between one type of plant growing on Organic soil with the same plant on Stockless soil

Plant type \ Regression Equation	F	P		R	F	P		R	F	P		R	F	P		R
		20%	5%			20%	5%			20%	5%			20%	5%	
O - O	1.09	9.5	161.5	N.S	8.18	9.5	161.5	N.S	2.09	9.5	161.5	N.S	1.03	2.1	4.3	N.S
M - M	1.30	"	"	N.S	1.25	"	"	N.S	2.62	"	"	N.S	1.00	"	"	N.S
S - S	1.38	"	"	N.S	1.25	"	"	N.S	1.35	"	"	N.S	1.57	"	"	N.S
Su - Su	3.78	"	"	N.S	3.27	"	"	N.S	1.09	"	"	N.S	2.30	"	"	**

Between each type of plant growing on Stockless soil without N.P.K. and the same on Stockless soil + 3 cwt. N.P.K.

Plant type	F	P 20%	P 5%	R	F	P 20%	P 5%	R	F	P 20%	P 5%	R	F	P 20%	P 5%	R
O - O	2.87	9.5	161.5	N.S	2.09	9.5	161.5	N.S	2.85	9.5	161.5	N.S	0.48	2.1	4.3	N.S
M - M	1.50	"	"	N.S	1.31	"	"	N.S	2.85	"	"	N.S	1.78	"	"	N.S
S - S	2.46	"	"	N.S	1.54	"	"	N.S	1.89	"	"	N.S	1.02	"	"	N.S
Su - Su	7.91	"	"	N.S	1.80	"	"	N.S	2.18	"	"	N.S	1.09	"	"	N.S

Between each type of plant growing on Stockless soil without N.P.K. and the same on Stockless soil + 5 cwt. N.P.K.

Plant type	F	P 20%	P 5%	R	F	P 20%	P 5%	R	F	P 20%	P 5%	R	F	P 20%	P 5%	R
O - O	1.77	9.5	161.5	N.S	1.55	9.5	161.5	N.S	1.58	9.5	161.5	N.S	1.07	2.1	4.3	N.S
M - M	4.60	"	"	N.S	1.13	"	"	N.S	4.62	"	"	N.S	1.95	"	"	N.S
S - S	1.08	"	"	N.S	1.18	"	"	N.S	3.09	"	"	N.S	1.22	"	"	N.S
Su - Su	1.07	"	"	N.S	1.57	"	"	N.S	1.36	"	"	N.S	1.01	"	"	N.S

F = Variance ratio
P = Probability value
R = Result of significance

** = Significance at 20% level
N.S = No significance at either 5% or 20% level

the performance of any of the seed types;

(2) the 30 year of 'cloning' the seeds have evolved no differences which are made evident at this level of growth analysis.

Perhaps most surprising is that the differences which appeared significant on consideration of the absolute data, are not borne out by the more sophisticated computer analysis of the growth data.

The absolute values compared were at one point of development of the crop, and a 'single feature' must be more susceptible to variations. On the other hand, the regression analysis takes the total performance into account for comparison.

(2) THE GEOCHEMICAL STATUS OF THE CROP

FIELD WORK

All the crops after mensuration were wet digested to allow analysis of their component geochemicals. For details of the methodology see appendix.

The progress curves for each geochemical studied are presented in Tables 64 to 64c/ see Appendix pages 296-299 and also are illustrated graphically in Figures 45 to 48. From data obtained, it was possible to make the following comparisons:

1) The geochemistry of each type of plant growing on the organic soil.

2) The geochemistry of each type of plant growing on the stockless soil without N.P.K. additions.

3) The geochemistry of each type of plant growing on the stockless soil treated with 3 cwt/acre N.P.K.

4) The geochemistry of each type of plant growing on the stockless soil treated with 5 cwt/acre N.P.K.

5) The geochemistry of each type of plant between the four soil treatments.

Thus for each geochemical analysed, it was possible to make the following comparisons:

Soil Treatments	Plant type O	M	S	Su

A = Organic soil

B = Stockless soil without N.P.K.

C = Stockless soil with 3cwt N.P.K.

D = Stockless soil with 5cwt N.P.K.

Using the means of the concentrations taken throughout the growing season, the results for nitrogen, nitrate and

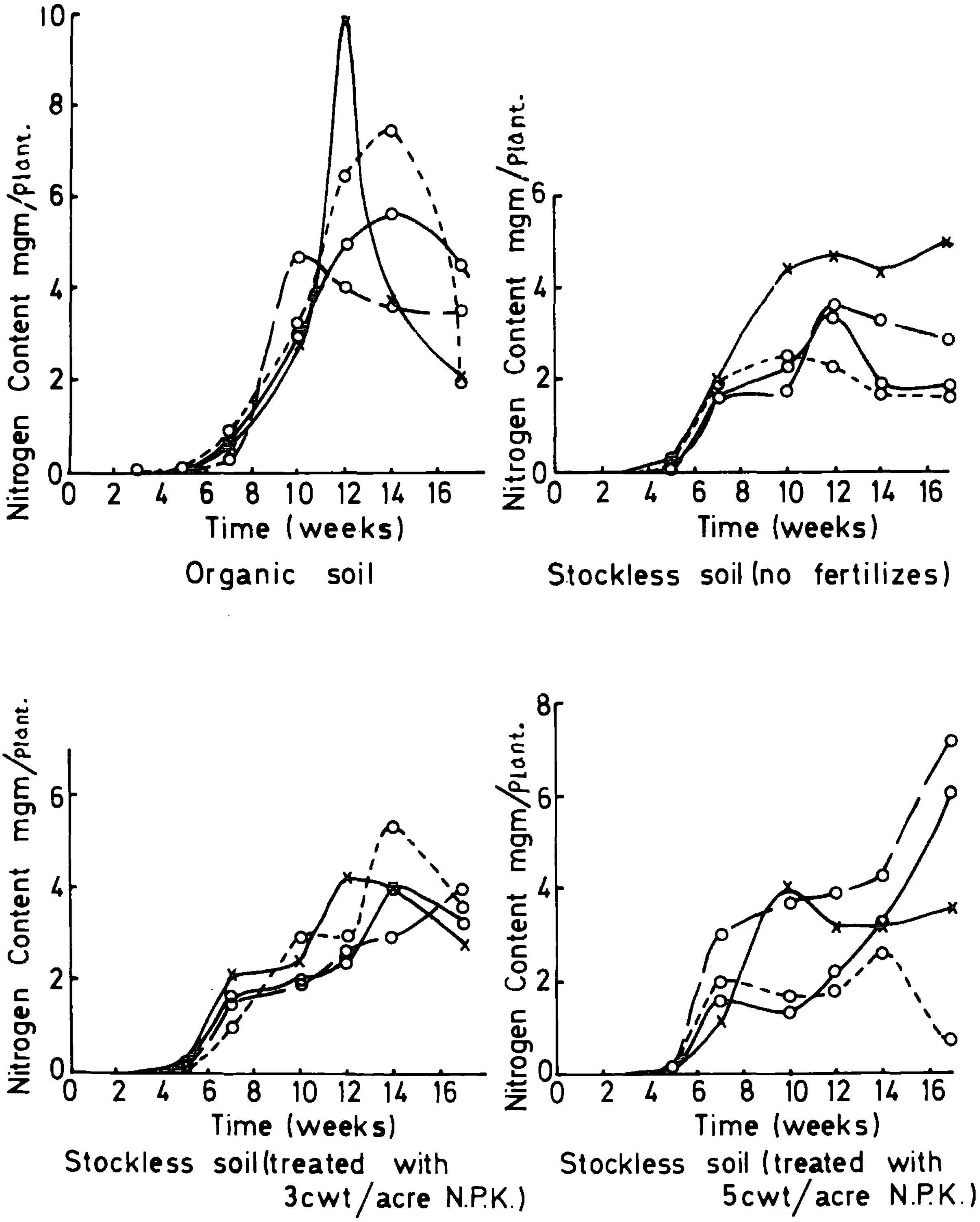


FIG. **45** Nitrogen Content of different kinds of Barley grown on Organic and Stockless soils.

o—o O Barley o—o M Barley o---o S Barley

x—x Sultan

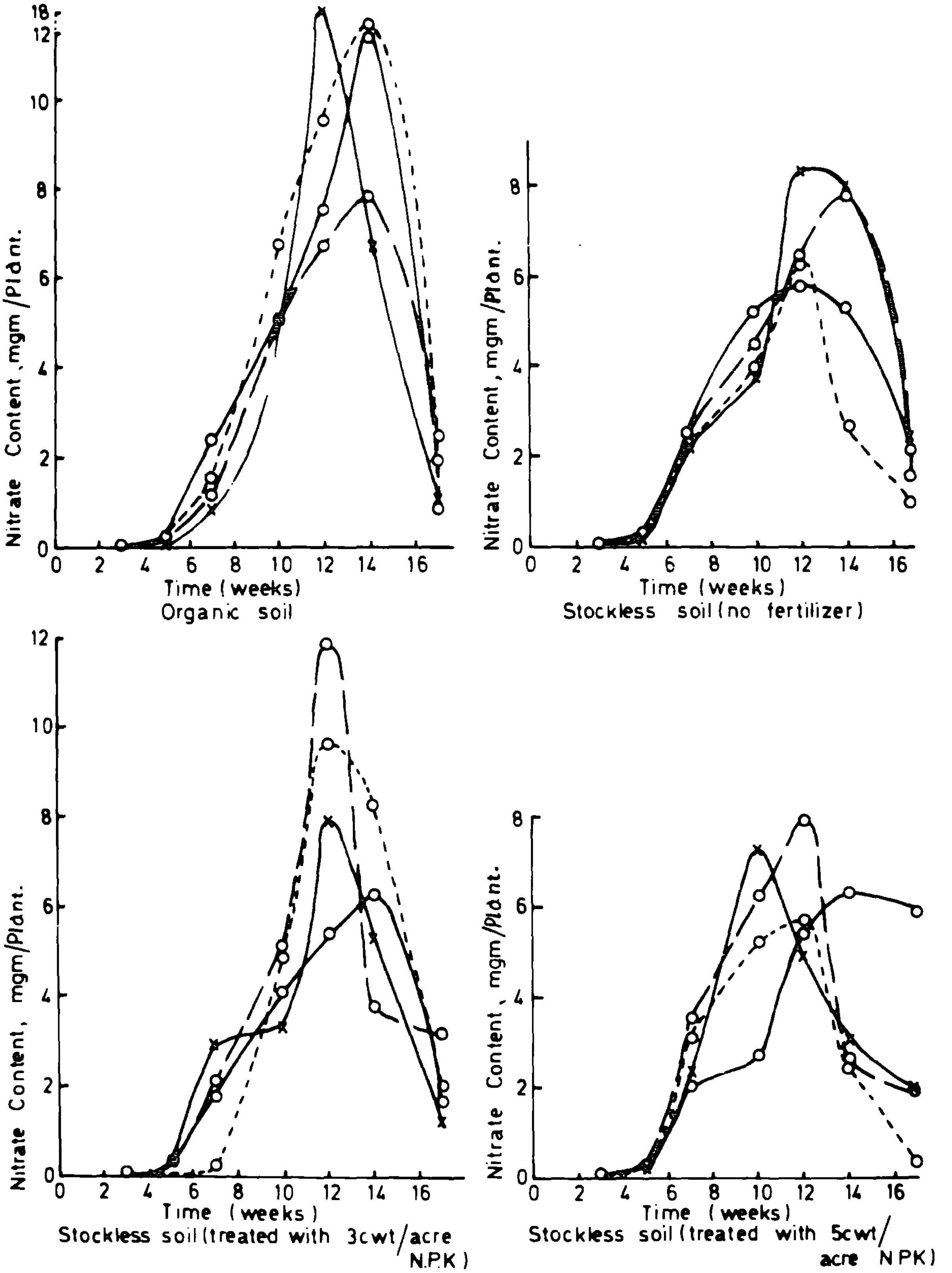


FIG. 46 Nitrate Content of different kinds of Barley grown on Organic and Stockless soils.

o—o O Barley. o—o M Barley. o----o S Barley.

x—x Sultan.

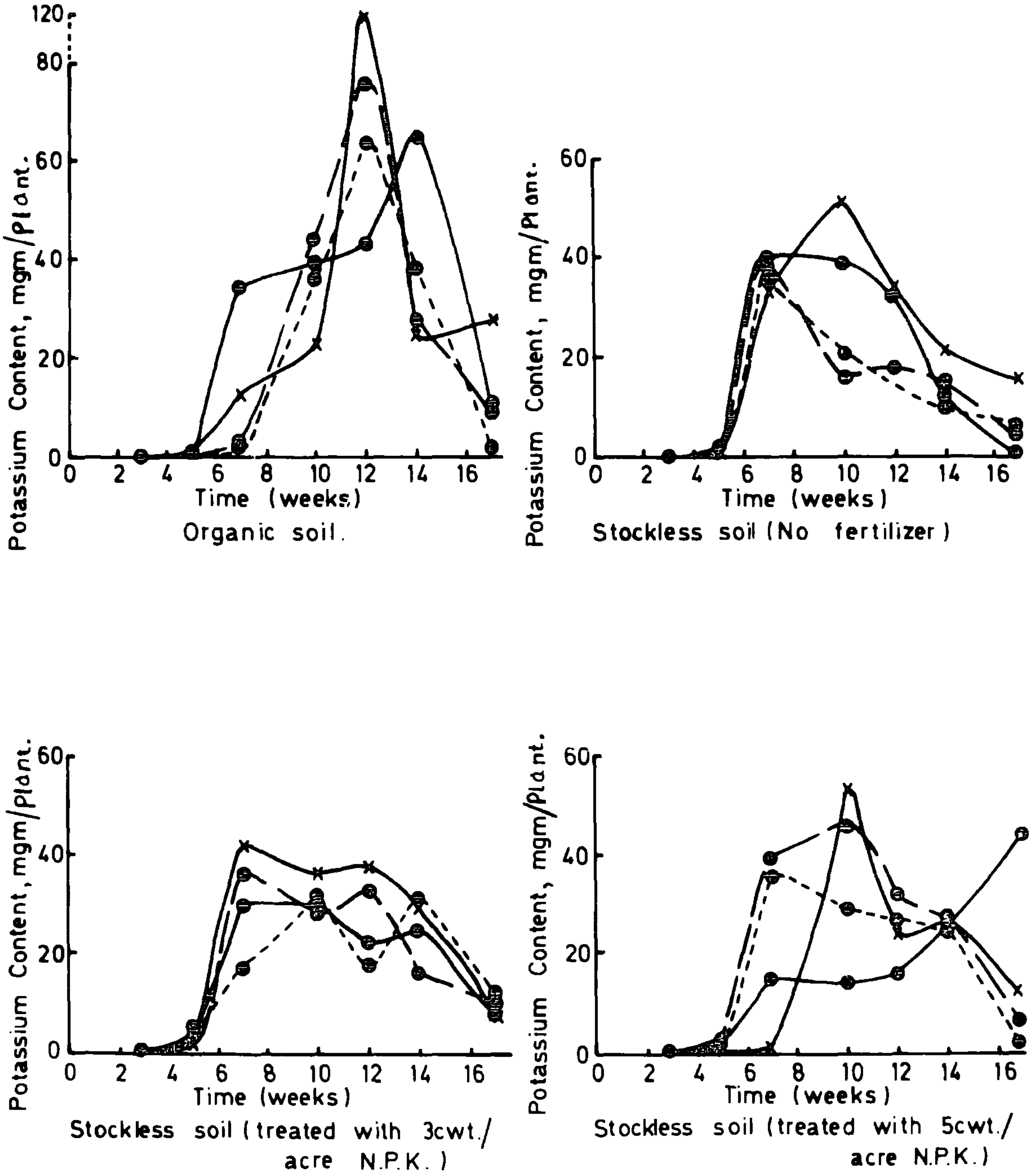


FIG.47 Potassium Content of different kinds of Barley grown on Organic and Stockless soil.

O Barley (Rika) — M Barley ---- S Barley

x (Sultan)

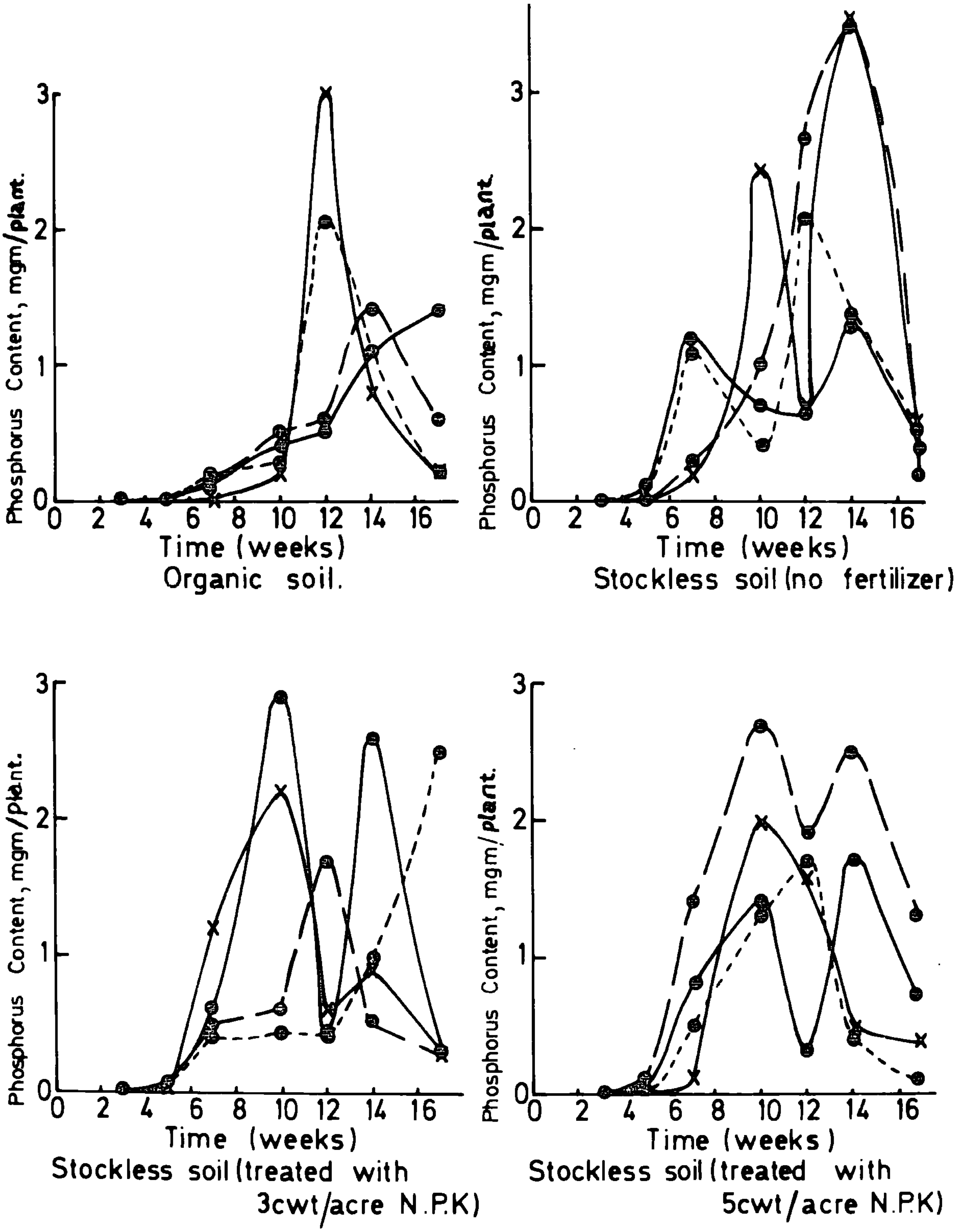


FIG. **48** Phosphorus Content of different kinds of Barley grown on Organic and Stockless soils.

●——● O Barley ●—●M Barley ⊙---⊙ S Barley ×——× Sultan and potassium either between plant types or between treatments did not show any significant differences. On the other hand the significant differences are found in the following geo-chemicals:

<u>Phosphorus</u>

Soil treatments	Plant type O	M	S	Su
A	0.9	0.5	0.6	0.66mg/plant
B	0.6	1.1	0.9	1.2 mg/plant
C	0.9	0.5	0.7	0.8 mg/plant
D	0.7	1.4	0.6	0.8 mg/plant

The significant differences are found only in the D treatment between:

Organic < Mixed
Mixed > Stockless
Mixed > Sultan

On testing the differences between treatments no significant differences are found. For details see Tables 65 and 65B.

<u>Calcium</u>

Soil treatments	Plant type O	M	S	Su
A	4.5	4.3	3.4	5.1 mg/plant
B	3.4	5.1	1.5	5.3 mg/plant
C	3.9	3.1	3.1	9.5 mg/plant
D	5.9	4.3	4.3	5.2 mg/plant

Summary table is shown above, for the means of the calcium concentrations in all different plant types. The significant differences (Table 65A) are found in the following treatments:

B

Organic < Mixed
Organic > Stockless
Organic < Sultan
Mixed > Stockless
Stockless < Sultan

TABLE 65

Crop Geochemistry

Test of significance between all plant types grown on different soil treatments. (Mean values are used)

Nutrient name	Plant type	Organic soil					Stockless without fertilizer					Stockless with 3 cwt. N.P.K.					Stockless with 5 cwt. N.P.K.				
		F	f_1	f_2	P	R	F	f_1	f_2	P	R	F	f_1	f_2	P	R	F	f_1	f_2	P	R
Nitrogen	O-M	0.319	12	12	2.69	N.S	0.286	12	11	2.79	N.S	0.135	12	11	2.79	N.S	0.864	12	11	2.79	N.S
	O-S	1.151	12	11	2.79	N.S	0.202	12	11	"	N.S	0.407	12	11	"	N.S	1.338	12	11	"	N.S
	O-Su	0.444	12	11	"	N.S	1.462	12	11	"	N.S	0.390	12	11	"	N.S	0.080	12	11	"	N.S
	M-S	0.429	12	11	"	N.S	0.568	12	11	"	N.S	0.287	12	11	"	N.S	2.067	12	11	"	N.S
	M-Su	0.375	12	11	"	N.S	1.165	12	11	"	N.S	0.291	12	11	"	N.S	0.869	12	11	"	N.S
	S-Su	0.160	12	11	"	N.S	1.681	12	11	"	N.S	0.060	12	11	"	N.S	1.254	12	11	"	N.S
Nitrate	O-M	0.503	12	11	2.79	N.S	0.190	12	11	2.79	N.S	0.554	12	11	2.79	N.S	0.246	12	11	2.79	N.S
	O-S	0.053	12	11	"	N.S	0.399	12	11	"	N.S	0.417	12	11	"	N.S	0.116	12	11	"	N.S
	O-Su	0.053	12	11	"	N.S	0.400	12	11	"	N.S	0.127	12	11	"	N.S	0.377	12	11	"	N.S
	M-S	0.142	12	11	"	N.S	0.631	12	11	"	N.S	0.099	12	11	"	N.S	0.527	12	11	"	N.S
	M-Su	0.209	12	11	"	N.S	0.166	12	11	"	N.S	0.226	12	11	"	N.S	0.177	12	11	"	N.S
	S-Su	0.038	12	11	"	N.S	0.735	12	11	"	N.S	0.397	12	11	"	N.S	0.118	12	11	"	N.S
Potassium	O-M	0.020	12	11	2.79	N.S	0.059	12	11	2.79	N.S	0.015	12	11	2.79	N.S	0.192	12	11	2.79	N.S
	O-S	0.038	12	11	"	N.S	0.072	12	11	"	N.S	0.020	12	11	"	N.S	0.149	12	11	"	N.S
	O-Su	0.054	12	11	"	N.S	0.045	12	11	"	N.S	0.083	12	11	"	N.S	0.103	12	11	"	N.S
	M-S	0.013	12	11	"	N.S	0.172	12	11	"	N.S	0.033	12	11	"	N.S	0.052	12	11	"	N.S
	M-Su	0.019	12	11	"	N.S	0.121	12	11	"	N.S	0.092	12	11	"	N.S	0.042	12	11	"	N.S
	S-Su	0.030	12	11	"	N.S	0.134	12	11	"	N.S	0.091	12	11	"	N.S	0.003	12	11	"	N.S
Phosphorus	O-M	0.875	12	11	2.79	N.S	1.837	12	11	2.79	N.S	2.174	12	11	2.79	N.S	3.333	12	11	2.79	*
	O-S	0.945	12	11	"	N.S	2.500	12	11	"	N.S	0.959	12	11	"	N.S	0.833	12	11	"	N.S
	O-Su	0.765	12	11	"	N.S	1.906	12	11	"	N.S	0.689	12	11	"	N.S	0.174	12	11	"	N.S
	M-S	0.476	12	11	"	N.S	0.224	12	11	"	N.S	1.111	12	11	"	N.S	3.478	12	11	"	*
	M-Su	0.345	12	11	"	N.S	0.712	12	11	"	N.S	2.143	12	11	"	N.S	2.692	12	11	"	*
	S-Su	0.153	12	11	"	N.S	0.815	12	11	"	N.S	0.476	12	11	"	N.S	0.563	12	11	"	N.S

F = Variance ratio
f_1, f_2 = Degrees of freedom
P = Probability value

R = Result of significance
* = Significance at 5% level
N.S = No " " " "

TABLE 65A

Crop Geochemistry

Test of significance between all plant types grown on different soil treatments
(Mean values are used)

Nutrient names	Plant type	Organic soil				Stockless without fertilizer				Stockless with 3 cwt. N.P.K.				Stockless with 5 cwt. N.P.K.			
		t	d.f	P	R	t	d.f	P	R	t	d.f	P	R	t	d.f	P	R
Calcium	O - M	1.71	4	2.776	N.S	3.50	4	2.776	*	2.22	4	2.776	N.S	1.42	4	2.776	N.S
	O - S	2.15	4	"	N.S	8.73	4	"	*	3.00	4	6.39	N.S	270.00	4	6.39	*
	O - Su	1.08	4	"	N.S	112.5	4	6.39	*	4.60	4	2.776	*	0.20	4	2.776	N.S
	M - S	1.26	4	"	N.S	25.00	4	2.776	*	1.80	4	"	N.S	3.13	4	"	*
	M - Su	1.87	4	"	N.S	2.40	4	"	N.S	140.00	4	6.39	*	2.00	4	"	N.S
	S - Su	2.33	4	"	N.S	10.40	4	"	*	4.00	4	2.776	*	12.50	4	"	*
Magnesium	O - M	1.14	4	2.776	N.S	2.33	4	2.776	N.S	2.39	4	2.776	N.S	4.40	4	2.776	*
	O - S	3.75	4	6.39	N.S	7.00	4	"	*	16.66	4	6.39	*	2.03	4	"	N.S
	O - Su	1.25	4	"	N.S	1.40	4	"	N.S	3.93	4	2.776	*	1.92	4	"	N.S
	M - S	13.50	4	"	*	3.50	4	"	*	1.88	4	"	N.S	5.92	4	"	*
	M - Su	5.50	4	2.776	*	2.80	4	"	*	1.56	4	"	N.S	30.77	4	"	*
	S - Su	3.00	4	6.39	N.S	9.80	4	"	*	1.09	4	"	N.S	1.42	4	"	N.S
Sodium	O - M	2.50	4	2.776	N.S	1.00	4	2.776	N.S	3.00	4	2.776	*	2.73	4	2.776	*
	O - S	0.31	4	"	N.S	4.00	4	"	*	1.00	4	"	N.S	1.00	4	"	N.S
	O - Su	6.00	4	"	*	89.17	4	"	*	1.00	4	"	N.S	1.50	4	"	N.S
	M - S	0.44	4	"	N.S	4.00	4	"	*	3.33	4	"	*	2.70	4	"	*
	M - Su	10.89	4	"	*	89.16	4	"	*	3.00	4	"	*	2.60	4	"	*
	S - Su	19.50	4	"	*	3.81	4	"	*	1.00	4	"	N.S	1.50	4	"	N.S

t = Students's
d.f = Degrees of freedom
P = Probability value
R = Result of significance

* = Significance at 5% level
N.S = No " " " "

Crop Geochemistry

Test of significance between all plant types between treatments.
(Mean values are used).

Field experiments

Nutrient details	Plant types	Organic soil vs. Stockless soil				Stockless soil without N.P.K. vs. soil with 3 cwt. N.P.K.				Stockless soil without N.P.K. vs. soil with 5 cwt. N.P.K.			
		t	d.f	P	R	t	d.f	P	R	t	d.f	P	R
Nitrogen	O-O	1.15	14	2.145	N.S	0.4	14	2.145	N.S	0.6	14	2.145	N.S
	M-M	0.44	"	"	N.S	0.3	"	"	N.S	1.6	"	"	N.S
	S-S	1.3	"	"	N.S	1.0	"	"	N.S	0.3	"	"	N.S
	Su-Su	0.06	"	"	N.S	0.7	"	"	N.S	0.7	"	"	N.S
Nitrate	O-O	0.6	14	2.145	N.S	0.2	14	2.145	N.S	0.1	14	2.145	N.S
	M-M	0.2	"	"	N.S	0.2	"	"	N.S	0.1	"	"	N.S
	S-S	1.1	"	"	N.S	0.7	"	"	N.S	0.04	"	"	N.S
	Su-Su	0.4	"	"	N.S	0.3	"	"	N.S	0.4	"	"	N.S
Potassium	O-O	0.8	14	2.145	N.S	0.14	14	2.145	N.S	0.14	14	2.145	N.S
	M-M	0.83	"	"	N.S	0.50	"	"	N.S	0.9	"	"	N.S
	S-S	0.7	"	"	N.S	0.40	"	"	N.S	0.6	"	"	N.S
	Su-Su	0.5	"	"	N.S	0.001	"	"	N.S	0.57	"	"	N.S
Phosphorus	O-O	1.2	14	2.145	N.S	0.6	14	2.145	N.S	0.3	14	2.145	N.S
	M-M	1.0	"	"	N.S	1.2	"	"	N.S	0.5	"	"	N.S
	S-S	0.8	"	"	N.S	0.4	"	"	N.S	0.8	"	"	N.S
	Su-Su	0.9	"	"	N.S	0.7	"	"	N.S	1.0	"	"	N.S
Calcium	O-O	0.5	14	2.145	N.S	0.3	14	2.145	N.S	0.5	14	2.145	N.S
	M-M	0.3	"	"	N.S	0.7	"	"	N.S	0.4	"	"	N.S
	S-S	1.3	"	"	N.S	1.3	"	"	N.S	1.9	"	"	N.S
	Su-Su	0.04	"	"	N.S	0.3	"	"	N.S	1.5	"	"	N.S
Magnesium	O-O	1.0	14	2.145	N.S	0.3	14	2.145	N.S	0.3	14	2.145	N.S
	M-M	0.5	"	"	N.S	0.7	"	"	N.S	1.3	"	"	N.S
	S-S	1.3	"	"	N.S	1.3	"	"	N.S	0.1	"	"	N.S
	Su-Su	0.0	"	"	N.S	0.8	"	"	N.S	0.8	"	""	N.S
Sodium	O-O	0.8	14	2.145	N.S	0.3	14	2.145	N.S	0.1	14	2.145	N.S.
	M-M	0.4	"	"	N.S	0.1	"	"	N.S	1.4	"	"	N.S
	S-S	1.9	"	"	N.S	1.7	"	"	N.S	1.0	"	"	N.S
	Su-Su	0.3	"	"	N.S	0.6	"	"	N.S	0.7	"	"	N.S

t = Students
d.f = Degrees of freedom
P = Probability value

R = Result of significance
N.S = No significance at 5% level

C

Organic < Sultan

Mixed < Sultan

Stockless < Sultan

D

Organic > Stockless

Mixed < Sultan

Stockless < Sultan

The test between each type of plants between treatments did not show any significant results. For details see Table 65B.

Magnesium

Summary table is shown below for all the means of the magnesium concentrations of all plant types taken throughout the growing season:

Soil treatments	Plant type				
	O	M	S	Su	
A	1.0	0.8	1.1	1.3	mg/plant
B	0.8	0.7	0.5	1.3	mg/plant
C	0.7	0.9	0.9	1.0	mg/plant
D	0.8	1.6	0.6	0.9	mg/plant

The results of significance test (table 65A) showed that:

A

Mixed < Stockless

Mixed < Sultan

B

Organic > Stockless

Mixed > Stockless

Mixed < Sultan

Stockless < Sultan

C

Organic < Stockless

Organic < Sultan

D

Organic $<$ Mixed

Mixed $>$ Stockless

Mixed $>$ Sultan

No significant differences are found between each type of plant between treatments. (See Table 65B).

Sodium

Table shown below is the summary of the means of all plant type (concentrations) taken throughout the growing season:

	Plant type				
Soil treatments	O	M	S	Su	
A	2.9	2.3	2.6	3.6	mg/plant
B	2.0	1.9	0.9	2.9	mg/plant
C	1.0	3.4	1.9	2.1	mg/plant
D	1.9	3.6	1.5	1.9	mg/plant

The results are recorded below and are significant at 5% level.

A

Organic $<$ Sultan

Mixed $<$ Sultan

Stockless $<$ Sultan

B

Organic $>$ Stockless

Organic $<$ Sultan

Mixed $>$ Stockless

Mixed $<$ Sultan

Stockless $<$ Sultan

C

Organic $<$ Mixed

Mixed $>$ Stockless

Mixed $>$ Sultan

D

Organic $<$ Mixed

Mixed $>$ Stockless

Mixed $>$ Sultan

No significant differences are found between treatments. For details see Table 65B.

The complete lack of pattern in these results and low levels of significance makes meaningful interpretation very difficult.

It was therefore decided to attempt comparisons based on the absolute maximum concentrations of the geochemicals attained regardless of the date on which they were attained. It was argued that the figure was comparable between treatments as it represented a particular state attained by the crop and the geochemical supply. As only one figure was available in each case and bearing in mind the lack of differences recorded between the barley types in the main body of the work, it was decided to lump the figures to allow statistical comparison.

Thus the four barley varieties were considered as a single phytometer.

TOTAL ORGANIC NITROGEN MAXIMUM VALUES OBTAINED

The summary table is shown below for the maximum concentrations of the total organic nitrogen:

Soil treatments	Plant type O	M	S	Su	
A	5.6	4.7	7.4	10.2	mg/plant
B	3.4	3.3	2.5	4.7	mg/plant
C	3.9	4.0	5.3	4.2	mg/plant
D	6.1	7.2	2.7	4.1	mg/ plant

Statistical analysis (table 66) showed that the significant difference was found only between:

A $>$ B

NITRATES MAXIMUM VALUES OBTAINED

Table is recorded below for the maximum concentrations of the nitrates:

Soil treatments	Plant type O	M	S	Su	
A	11.4	7.2	12.3	18.3	mg/plant
B	5.8	5.8	6.5	8.4	mg/plant
C	6.3	11.9	9.6	7.9	mg/plant
D	6.8	7.9	5.7	7.3	mg/plant

Statistical analysis (Table 66) showed no significant differences were recorded.

POTASSIUM MAXIMUM VALUES OBTAINED

Summary table is shown below for all potassium concentration of all plant types at maximum values:

Soil treatments	Plant type O	M	S	Su	
A	65.0	76.2	64.7	120.0	mg/plant
B	40.2	39.5	36.7	51.0	mg/plant
C	30.4	36.7	32.1	42.2	mg/plant
D	40:2	45.5	35.8	53.3	mg/plant

Analysis of signifance (Table 66) showed that the only significant differences are found between:

A $>$ B

PHOSPHORUS MAXIMUM VALUES OBTAINED

Data shown below are the maximum concentrations of phosphorus in all plant types:

Soil treatments	Plant type O	M	S	Su	
A	1.4	1.4	2.2	3.1	mg/plant
B	1.4	3.9	2.1	3.9	mg/plant
C	2.9	1.7	2.5	2.2	mg/plant
D	1.7	2.8	1.7	2.6	mg/plant

TABLE 66

Crop Geochemistry

Test of significance between soil treatments using the four plant types as one phytometer (Field experiments)

Nutrient details	Organic soil vs. Stockless soil				Stockless soil without N.P.K. vs. soil with 3 cwt. N.P.K.				Stockless soil without N.P.K. vs. soil with 5 cwt. N.P.K.			
	t	d.f	P	R	t	d.f	P	R	t	d.f	P	R
N	2.6	14	2.45	*	1.1	14	2.45	N.S	1.2	14	2.45	N.S
NO_3	2.2	"	"	N.S	1.2	"	"	N.S	0.2	"	"	N.S
K	8.0	"	"	*	1.1	"	"	N.S	0.5	"	"	N.S
P	0.9	"	"	N.S	0.6	"	"	N.S	1.0	"	"	N.S
Ca	2.1	"	"	N.S	0.3	"	"	N.S	0.5	"	"	N.S
Mg	0.9	"	"	N.S	0.3	"	"	N.S	1.1	"	"	N.S
Na	1.9	"	"	N.S	0.4	"	"	N.S	0.1	"	"	N.S

t = Students
d.f = Degrees of freedom
P = Probability value

R = Result of significance
* = Significance at 5% level
N.S = No significance at 5% level

No significant differences (Table 66) were recorded.

CALCIUM MAXIMUM VALUES OBTAINED

Concentrations of calcium in all plant types at maximum values are shown below in summary table:

Soil treatments	Plant type O	M	S	Su	
A	14.2	12.1	11.6	13.9	mg/plant
B	6.4	10.7	4.6	11.0	mg/plant
C	7.1	6.1	7.5	12.1	mg/plant
D	9.3	8.0	14.7	6.5	mg/plant

No significant differences were recorded. For details see Table 66.

MAGNESIUM MAXIMUM VALUES OBTAINED

The maximum values of magnesium in all plant types are summarized below:

Soil treatments	Plant type O	M	S	Su	
A	3.6	2.3	3.3	4.5	mg/plant
B	1.3	1.4	0.9	2.9	mg/plant
C	2.1	1.8	2.6	1.9	mg/plant
D	2.2	5.9	1.3	1.9	mg/plant

The statistical analysis (Table 66) showed no significant differences were recorded.

SODIUM MAXIMUM VALUES OBTAINED

Summary table is shown below for all maximum concentrations of sodium in all plant types.

Soil treatments	Plant type O	M	S	Su	
A	8.3	7.8	9.8	14.1	mg/plant
B	3.4	3.4	2.4	10.4	mg/plant
C	4.4	4.7	3.4	4.0	mg/plant
D	4.0	7.7	4.0	3.7	mg/plant

No significant differences (Table 66) were found.

Despite the few differences found in the geochemicals of the crops in the field experiments,the results of the analysis of the plant in the 1971 pot experiments (see section3) are reported below:

In the greenhouse experiments, O,M, and S seeds were grown in the pots of stockless and organic soils arranged in latin squares. The samples harvested at weekly intervals were after mensuration analysed for their component geochemicals after wet digestion. The progress curves for each geochemical studied are presented in Figures **49** to **50**, and the data in Tables 67 to 67A.

The data allowed the following comparisons to be made:

1) The geochemicals of each type of plant grown on the organic soil.

2) The geochemicals of each type of plant grown on the stockless soil.

3) The geochemicals of each type of plant between treatments.

4) Due to the lack of replicates, statistical comparison of the maximum values of each geochemical are impossible. The example of the field experiment, pages 138-152 was followed and the three barley types used as one phytometer to allow more meaningful comparisons.

<u>TOTAL ORGANIC NITROGEN</u>

Using the means of the concentrations.

Soil treatment	Plant type O	M	S	
Organic	0.10	0.08	0.16	mg/plant
Stockless	0.12	0.09	0.07	mg/plant

In the summary table shown above no significant differences

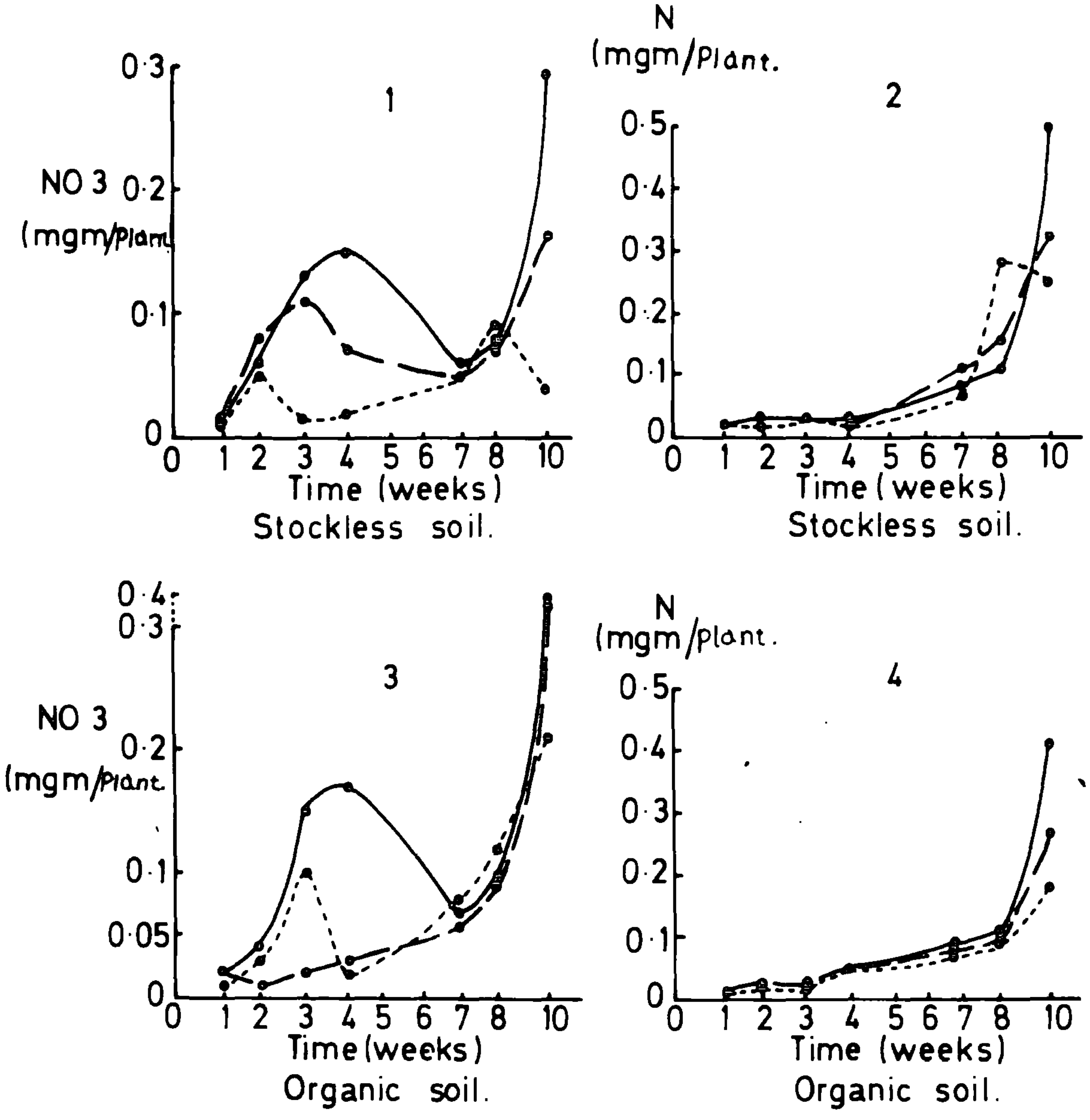


FIG.49 Nutrient Content of different kinds of Barley grown on two types of soil. (1&2 on Stockless, 3&4 on Organic) expressed as mgm/Plant.

●——● O Barley. ●— —● M Barley. ●- - - -● S Barley.

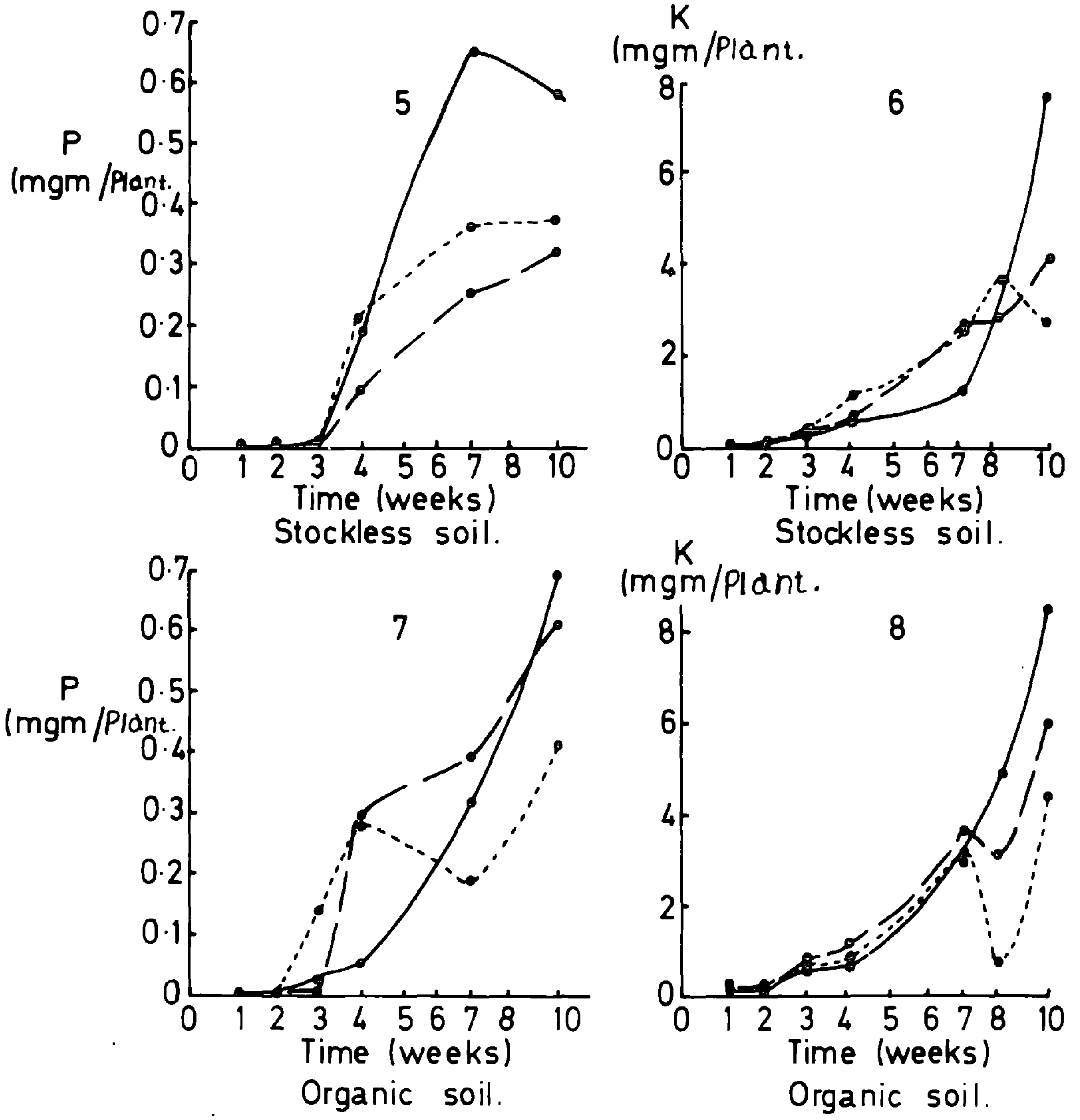


FIG.50 Nutrient Content of different kinds of Barley grown on two types of soil. (5& 6 on Stockless, 7&8 on Organic) expressed as mgm/Plant.

●——● O Barley. ●— —● M Barley. ●----● S Barley.

TABLE 67

Crop Geochemistry

Concentration of the geochemicals of the three different plants grown on the two different soils in the greenhouse.

Date (weeks)	Nitrogen			Nitrate			Potassium			Phosphorus			Calcium		
	O	M	S	O	M	S	O	M	S	O	M	S	O	M	S
ORGANIC SOIL															
1	0.013	0.019	0.026	0.021	0.027	0.018	0.071	0.105	0.061	0.002	0.0019	0.004	0.069	0.011	0.079
2	0.018	0.034	0.028	0.043	0.006	0.036	0.109	0.112	0.106	0.0035	0.007	0.004	0.158	0.161	0.115
3	0.039	0.024	0.040	0.154	0.015	0.133	0.498	0.706	0.610	0.034	0.098	0.137	0.274	0.290	0.146
4	0.046	0.049	0.046	0.217	0.0251	0.021	0.557	1.324	1.079	0.052	0.309	0.284	0.580	0.799	0.609
6	0.086	0.089	0.069	0.075	0.061	0.057	3.033	3.633*	3.738	0.322	0.387	0.188	1.588	2.937	1.227
7	0.113	0.098	0.096	0.126	0.096	0.119	5.331	2.887	0.651	-	-	-	4.654	2.643*	1.382
10	0.407*	0.277*	0.189*	0.410*	0.404*	0.212*	8.795*	0.626	4.474*	0.708*	0.611*	0.407*	4.681*	1.379	2.142*
Mean ±	0.103	0.084	0.164	0.146	0.096	0.085	2.627	1.342	1.531	0.186	0.235	0.171	2.001	1.537	0.963
S.E	0.09	0.058	0.041	0.871	0.053	0.026	1.263	0.526	0.681	0.114	0.099	0.065	0.866	0.588	0.308
St. Dev.	0.24	0.154	0.109	2.300	0.141	0.070	3.347	1.390	1.805	0.281	0.242	0.158	2.122	1.441	0.755
STOCKLESS SOIL															
1	0.017	0.015	0.029	0.016	0.021	0.180	0.073	0.081	0.079	0.003	0.004	0.003	0.074	0.072	0.079
2	0.025	0.034	0.025	0.063	0.082	0.054	0.118	0.121	0.135	0.005	0.005	0.004	0.167	0.129	0.009
3	0.028	0.034	0.031	0.132	0.116	0.013	0.353	0.387	0.357	0.009	0.049	0.009	0.200	0.183	0.179
4	0.023	0.016	0.045	0.149	0.069	0.019	0.718	0.949	1.323	0.191	0.098	0.216	0.249	0.280	0.608
6	0.075	0.107	0.069	0.057	0.045	0.053	1.411	2.890	2.627	0.658*	0.253	0.362	0.323	1.047	1.976
7	0.102	0.148	0.028	0.085	0.073	0.098*	3.918	2.935	3.975*	-	-	-	0.772	1.769*	1.199
10	0.537*	0.327*	0.255*	0.285*	0.166*	0.042	6.875*	4.107*	2.954	0.576	0.315*	0.925*	2.485*	1.619	2.477*
Mean ±	0.117	0.092	0.069	0.112	0.082	0.066	1.924	1.639	1.636	0.240	0.130	0.253	0.610	0.728	0.932
S.E	0.071	0.043	0.029	0.033	0.018	0.022	0.967	0.618	0.576	0.123	0.045	0.147	0.323	0.278	0.371
St. Dev.	0.187	0.113	0.078	0.088	0.047	0.057	2.561	1.639	1.527	0.301	0.110	0.360	0.857	0.738	0.983

All concentrations as mg/plant

(O, M, S) = Barley var. 'Rika'
S.E = Standard error
St. Dev. = Standard deviation
* = Maximum concentrations

TABLE 67A

Crop Geochemistry

Concentration of the geochemicals of the three different plants grown on the two soils in the greenhouse.

Date (Weeks)	Organic soil			Stockless soil			Organic soil			Stockless soil		
	Magnesium			Magnesium			Sodium			Sodium		
	O	M	S	O	M	S	O	M	S	O	M	S
1	0.017	0.025	0.018	0.022	0.015	0.039	0.066	0.097	0.057	0.065	0.063	0.072
2	0.017	0.013	0.015	0.017	0.017	0.016	0.085	0.087	0.070	0.075	0.077	0.061
3	0.076	0.161	0.071	0.033	0.033	0.039	0.196	0.387	0.277	0.110	0.094	0.213
4	0.058	0.078	0.149	0.003	0.094	0.143	0.269	0.699	0.454	0.172	0.131	0.269
6	0.344	0.387*	0.285	0.129	0.255	0.165	1.033	0.850	1.052	0.377	0.336	0.421
7	0.602	0.362	0.174	6.258	0.323	0.356	1.134	0.978*	1.520*	0.341	0.426	0.692*
10	1.126*	0.301	0.475*	0.675*	0.673*	0.495*	2.479*	0.451	0.603	1.242*	1.039*	0.603
Mean ±	0.320	0.190	0.170	0.160	0.201	0.179	0.756	0.550	0.576	0.340	0.302	0.333
S.E	0.157	0.06	0.062	0.093	0.091	0.069	0.332	0.133	0.204	0.157	0.135	0.094
St. Dev.	0.417	0.160	0.165	0.245	0.241	0.182	0.879	0.352	0.540	0.417	0.357	0.248

All concentrations as mg/plant

(O, M, S) = Barley var. 'Rika'

S.E = Standard error

St. Dev. = Standard deviation

* = Maximum concentrations

are obtained between all the means of all plant types either for plants grown on the organic soil or on the stockless soil (Table 68). Also, no significant differences are shown between the means of each type of plants grown on extreme soils. For details see Table 68_a.

The maximum concentrations are shown below:

Soil treatments	Plant type O	M	S	
Organic	0.41	0.28	0.19	mg/plant
Stockless	0.54	0.33	0.26	mg/plant

No significant differences are found between the soil treatments. See Table 68_b.

Nitrates

A summary table is shown below for all the means of the nitrate concentrations obtained over the experimental period:

Soil treatments	Plant type O	M	S	
Organic	0.15	0.09	0.08	mg/plant
Stockless	0.12	0.08	0.07	mg/plant

The significant differences are shown on the organic soil between the means of:

Organic > Mixed

Organic > Stockless

On the other hand, no significant differences are recorded for plants grown on the stockless soil (Table 68). On testing the differences between the soil treatments, the results showed that the organic plants grown on the organic soil are significantly higher from those on the stockless soil.

The maximum values are recorded in summary table below:

TABLE 68

Crop Geochemistry

Test of significance between all plant types grown on Organic and Stockless soil. (Mean values are used)

Organic soil

Plant type / Nutrient details	O - M				O - S				M - S			
	t	d.f	P	R	t	d.f	P	R	t	d.f	P	R
N	0.12	4	2.776	N.S	0.38	4	2.776	N.S	0.80	4	2.776	N.S
NO_3-N	16.43	"	"	*	32.86	"	"	*	2.00	"	"	N.S
K	2.54	"	"	N.S	1.83	"	"	N.S	1.38	"	"	N.S
P	1.16	"	"	N.S	1.78	"	"	N.S	1.53	"	"	N.S
Ca	1.44	"	"	N.S	2.65	"	"	*	1.80	"	"	N.S
Mg	2.00	"	"	N.S	2.00	"	"	N.S	2.00	"	"	N.S
Na	2.25	"	"	N.S	1.65	"	"	N.S	1.25	"	"	N.S

Stockless soil

N	0.21	4	2.776	N.S	2.39	4	2.776	N.S	1.45	4	2.776	N.S
NO_3-N	1.87	"	"	N.S	1.54	"	"	N.S	1.21	"	"	N.S
K	2.54	4	"	N.S	1.83	"	"	N.S	1.38	"	"	N.S
P	2.74	"	"	*	1.20	"	"	N.S	3.27	"	"	*
Ca	1.13	"	"	N.S	1.13	"	"	N.S	1.14	"	"	N.S
Mg	1.04	"	"	N.S	1.39	"	"	N.S	1.32	"	"	N.S
Na	1.33	"	"	N.S	1.67	"	"	N.S	1.00	"	"	N.S

t = Students
d.f = Degrees of freedom
P = Probability value

R = Result of significance
* = Significance difference at 5% level
N.S = No " " " " "

TABLE 68a

Crop Geochemistry

Test of significance between all different types of plant grown on Organic and Stockless soils

Nutrient detail	Plant type	Organic soil versus Stockless soil			
		t	d.f	P	R
N	O - O	1.20	4	2.776	N.S
	M - M	1.33	4	"	N.S
	S - S	1.39	4	"	N.S
NO_3-N	O - O	25.56	4	2.776	*
	M - M	1.00	4	"	N.S
	S - S	1.22	4	"	N.S
K	O - O	0.79	4	2.776	N.S
	M - M	1.23	4	"	N.S
	S - S	1.20	4	"	N.S
P	O - O	1.07	4	2.776	N.S
	M - M	2.20	4	"	N.S
	S - S	2.28	4	"	N.S
Ca	O - O	2.65	4	2.776	N.S
	M - M	2.00	4	"	N.S
	S - S	1.33	4	"	*
Mg	O - O	2.00	4	2.776	N.S
	M - M	1.50	4	"	N.S
	S - S	1.12	4	"	N.S
Na	O - O	2.25	4	2.776	N.S
	M - M	1.25	4	"	N.S
	S - S	2.25	4	"	N.S

t = Students
d.f = Degrees of freedom
P = Probability value
R = Result of significance
* = Significance at 5% level
N.S = No " " " "

TABLE 68b

Crop Geochemistry

Test of significance between the two types of soil (Organic and Stockless) using the three types of plant as phytometer.

Greenhouse experiment

Nutrient details	Organic vs. Stockless			
	t	d.f	P	R
Nitrogen	1.0	14	2.45	N.S
Nitrate	4.0	"	"	*
Potassium	0.3	"	"	N.S
Phosphorus	0.6	"	"	N.S
Calcium	1.1	"	"	N.S
Magnesium	0.5	"	"	N.S
Sodium	1.8	"	"	N.S

t = Students
d.f = Degrees of freedom
P = Probability value
R = Result of significance
* = Significance at 5% level
N.S = No significance at 5% level

Soil treatments	Plant type O	M	S	
Organic	0.41	0.40	0.21	mg/plant
Stockless	0.29	0.17	0.04	mg/plant

In all plants highest values were obtained on the organic soil. Table 68b shows that the differences are significantly higher values for plants grown on the organic soil from those on the stockless soil.

Potassium

Recorded below are the means of all concentrations of potassium obtained throughout the experimental period:

Soil treatments	Plant type O	M	S	
Organic	2.6	1.3	1.5	mg/plant
Stockless	1.9	1.6	1.6	mg/plant

No significant differences are found either between the means of all plant types grown on organic or on stockless soils, or between the means of each type grown on different soil treatments. For details see Tables 68 and 68a.

The maximum values obtained are shown below:

Soil treatments	Plant type O	M	S	
Organic	8.8	4.5	3.6	mg/plant
Stockless	6.9	4.1	3.0	mg/plant

All maximum values of all plant types showed no significant differences between the soil treatments (see Table 68b).

Phosphorus

Data shown below are the means of the concentration of phosphorus throughout the experimental period:

Soil treatments	Plant type O	M	S	
Organic	0.19	0.24	0.17	mg/plant
Stockless	0.24	0.13	0.25	mg/plant

The analysis of significance (Table 68) showed that:
On the organic soil -no significant differences are found between the means of all plant types.
On the stockless soil -the differences that showed significance are recorded between:

Organic > Mixed

Mixed < Stockless

No significant differences are found between each type of plant on different treatments. The values of phosphorus at maximum levels are tabulated below:

Soil treatments	Plant type O	M	S	
Organic	0.71	0.61	0.41	mg/plant
Stockless	0.66	0.32	0.93	mg/plant

No significant differences are obtained between the two different soils. For details see Table 68b.

Calcium

Data for all the means are shown below:

Soil treatments	Plant type O	M	S	
Organic	2.0	1.5	0.9	mg/plant
Stockless	2.5	1.8	2.5	mg/plant

The only significant difference was found between the organic and stockless plants recording the highest values for the organic plants.

The differences are significantly higher for the stockless plants on the stockless soil than the same plants grown on the organic soil. See Table 68a.

The maximum concentrations of calcium are shown below:

Soil treatments	Plant type O	M	S	
Organic	4.7	3.6	2.1	mg/plant
Stockless	2.5	1.8	2.5	mg/plant

The significant test (Table 68b) showed no significant differences are found between the two soils.

Magnesium

Data presented below are the means of the magnesium concentrations of all plant types:

Soil treatments	Plant type O	M	S	
Organic	0.32	0.19	0.17	mg/plant
Stockless	0.16	0.20	0.18	mg/plant

The analysis of significance did not show any significant differences either between the plant types grown on the organic or on the stockless soils (see Table 68). Also, no significant differenceswere found between the soil treatments. The concentration of magnesium at maximum values are shown in summary table below:

Soil treatments	Plant type O	M	S	
Organic	1.13	0.4	0.5	mg/plant
Stockless	0.7	0.7	0.5	mg/plant

The significant test (Table 68b) did not show any significant differences.

Sodium

The summary table below shows all the means of all concentrations of all plant types:

Soil treatments	Plant types O	M	S	
Organic	0.8	0.6	0.6	mg/plant
Stockless	0.3	0.3	0.3	mg/plant

No significant differences are found between all plant types on both soils or between treatments (See Tables 68 to 68a).

The maximum concentrations of sodium are tabulated below:

Soil treatments	Plant types O	M	S	
Organic	2.5	1.5	1.0	mg/plant
Stockless	1.2	1.0	0.7	mg/plant

No significant differences are found between the two soil treatments. For details see Table 68b.

INFERENCES FROM BOTH SECTIONS

The comparisons based on the mean levels of geochemicals are very inconclusive.

Out of the possible 168 comparisons, only 39 reach significance and only 3 of these relate to the specific nutrients N.P.K.

The lack of overall pattern in these results indicate that even at the physiological level none of the "cloned" varieties show as "preference" for any of the treatment at least with regard to the uptake of the geochemicals studied.

These finds are borne out by the greenhouse experiments. Where even fewer (5 out of a total 42) comparisons attain significance.

Turning to the data on the maximum concentrations of the geochemicals attained by the crops, in both sets of experiments in the few cases in which significant differences were recorded, they do indicate higher levels of the geochemicals in the plant grown on the organic soil.

The most interesting feature is that the plants grown on the high fertilizer treatment stockless soil do not show consistently higher levels of geochemicals than those grown on the untreated stockless soil. The latter points to the fact that the stockless soil system must provide sufficient geochemicals for the adequate performance of the crops and that the levels of fertilizer applications were not large enough to evoke a eutrophication response.

It is of interest that Bishop, et.al. (1971) working on barley showed that N.P.K. added at the rate of 135, 39,37 Kg/ha were in general sufficient for barley. Comparable figures for the Haughley systems are:

	N	P	K	
Organic	43.9	43.0	23.0	Kg/ha
Stockless	50.0	25.0	25.0	Kg/ha
Stockless+3cwt	75.0	37.7	37.7	Kg/ha
Stockless+5cwt	125.5	62.8	62.8	Kg/ha
Bishops	135.0	39.0	37.0	Kg/ha

In the majority of cases reported in the literature, Pendleton, et.al. (1953), Kirby E.M. (1968), Bhatnagar et.al. (1957) and Bishop et. al. (1971), the response of Barley to fertilizer applications have been assessed in relation to yield of grain. The experiments as set out above were not designed to allow such comparisions for these have been carried out extensively in the main Haughley experiments.

These are summarized below:

Figures taken from Haughley experimental farm:

	Organic	Mixed	Stockless	
1971	19.8	15.3	26.5	cwt./acre
1972	30.0	24.0	32.0	cwt./acre

SECTION IV DISCUSSION

As brief discussion of the results have been included at the end of each of the main sections, the aim of the discussion is to attempt to draw together the threads of the wide ranging project.

As pointed out in the introduction, the work as envisaged was to be a broad based screening operation to ascertain what differences, if any, exist between the three farm systems at Haughley. The basis of the work was the use of Barley var. RIKA as a phytometer to asses differences measured both at the performance level by growth analysis, and at the physiological level, by geochemical analysis of crop tissues. The first question to be answered however related to the possible development of differences between the barley which had been grown as "clones" on the three farm systems over the 32 years of the main experiment.

Out of all the experiments, no clear differences became evident, apart from a slight indication that the organic seeds perform better on all type of soils when compared with the stockless and mixed seeds (fig. 34 to 35).

In no case did either the organic, mixed or stockless seeds perform either better or worse, nor show a significantly different pattern of uptake of the geochemicals when grown on their own soil systems. The indication is therefore that no "dependance" of the barley 'clones' to the farm systems has developed over 32 years of differing management.

It thus became possible to bulk the results of the "barley clones" to allow more meaningful statistical treatment (section3). Although change in the Haughley Research Farm policy in the middle of the current series of experiments, made it impossible to repeat the experiments in the following year, it at least allowed one new variety, the var. SULTAN, to be used in the field as a phytometer to back up the findings based on the 'cloned' RIKA.

The results from the main phytometeric studies fall into three main groups:

1) Those from the greenhouse experiments in which differences of the plants both at the stages of germination (Fig. 31) ecesis (Fig 32-33) establishment and early vegetative growth. Wherever these differences reached significance, it was always the organic plants or the plants growing on the organic soil which showed the best performance (Fig. 32-33 and Tables 51, 53).

2) The absolute data (Fig. 39-40) from the field experiments, strengthened the above findings for wherever significant differences were recorded, the performance of the plants assessed both as maximum dry weight and maximum leaf area were greatest on the organic systems (Table 58).

3) The mean data derived from the field experiments, especially the overall similarity of the computer generated growth curves (Fig. 41-44) and the few cases and the low levels of significance found between the regression equations:

1) Backed up the conclusion that the performance of the three barley 'clones' differ so little that they could be regarded as a single phytometer for further comparative work.

2) Indications that there are no marked difference between the three farm systems as assessed by the phytometer employed.

There is however again the hint of significantly higher performances (measured as dry weight) of both the organic and sultan seeds when grown on the organic system when compared to those grown on the stockless system (Table **57**).

GEOCHEMISTRY

Turning to the crop geochemistry, the results are even more inconclusive. The most surprising results being that the crop grown on the high fertilizer treatment (stockless soil with 5 cwt/acre N.P.K.) showed no significantly higher levels of geochemicals than those grown on control stockless soil (Figs. 45 to 48). Review of earlier litratures, see appendix (section V), does not help in the interpretation as different workers have obtained different responses of barley to addition of various amounts of N.P.K. fertilizers, none specifically refering to crop geochemistry.

The indication is however, that the stockless system as constituted at Haughley provides both the RIKA and SULTAN with sufficient of the geochemicals studies, and that an additional 5 cwt/acre N.P.K. is insufficient to saturate the soil crop system evoking increased uptake (eutrophication) by the crop.

There is, however, again an indication of an "effect." In the comparison of the maximum concentrations of the geochemicals in the barley tissues. In the few cases when significant differences are recorded, the plants grown on the organic soil are richer than those grown on the stockless soil. The two geochemicals in question being total organic nitrogen and potassium.

It is interesting,though somewhat ironical (as the data were simply collected as on adjunct to the main study) that the background data collected from the soils are more conclusive and in fact, back up the slight positive attributes of the organic system indicated by phytometry.

The significantly higher levels of organic matter, organic nitrogen (Table 1-2 and Figs 2-3) and available potassium, phosphorus, ammonia mitrogen and nitrate nitrogen (Table 6-26 and Figs. 3-11), point to the fact that the organic soil may be a better medium for growth than the stockless soil. These differences could easily account for the better performance and higher level of geochemicals recorded from the organic system.

These findings also correlate with those of the total loss of geochemicals to gravitational water from the organic soil in the lysimeter experiments. The only significant difference (Table 37a) showed greater losses from the organic soil compared with the stockless (Table 37-42). The fact that in an almost equal number of cases of significantly higher losses of geochemicals were recorded from the high fertilizer treatment (stockless with 7.2 cwt/acre N.P.K.) when compared with stockless control (Tables 37a) is of interest. It would seem safe to conclude that certain of the geochemicals present in the organic soil are more readily "available" to leaching than they are in the mixed and stockless fields.

Inspection of the progress curves (Figs 45-50) for the geochemicals present in the crops, show less fluctuation for the plants growing on the organic soil than on any of the stockless treatments. The simplest explanation would be that the organic manures release their geochemicals more evenly than the inorganic fertilizer used on the stockless field. This is, however, not altogether borne out by the progress curves for the geochemicals in the soil systems throughout the growing period when for most of the geochemicals equally smooth "curves" are obtained.

The results for potential nitrogen fixation (Table 34 and Figs. 12-19) and dentrification (Table 48 and Figs. 29-30) are in accordance with the differences recorded above for the geochemistry of the soil systems. The complete lack of acetylene reduction by all three soils under field conditions (that is in the absence of added glucose) throughout the growing season 1973, points to the fact that nitrogen fixation by soil micro-organisms is of little importance in the Haughley systems.

Without doubt the most difficult phenomena to explain are the differences shown between certain of the total geochemicals present in the three systems.

Analysis of the data undoubtedly shows that the organic soils have significantly more total Ca, Mg and K (Table 5) and significantly less Zn and Cu than the stockless soils. The mixed soil is in a somewhat intermediate position (see progress curves figs. 6 to 7). The question is, can these differences be related to the 32 years of differing experimental management? The excess of Zn and Cu on the stockless soil has already been tentatively explained as due to addition in the agricultural chemicals. The higher values of Ca, Mg and K are more puzzling.

Total geochemicals, as analysed for, include all the geochemicals present in the soil including the unweathered parent material. It is usually the case that the bulk of geochemicals like Ca, Mg and K are present in the parent material from which they are released by natural weathering into the exchangeable form in which they are available to plant growth and to leaching. It is easy to understand how the exchangeable geochemicals could be affected by long term management, but not so easy to comprehend such an effect on the non-exchangeable fraction. The following explanation in tentatively advanced.

Apart from the chemical properties of the soil measured, the soils on the three sections at Haughley do differ visibly in a number of ways, the most striking differences being between the organic and mixed, on the one hand, and the stockless field on the other:

1) The stockless field has much less visible structure and when put to plough the surface of the lumps of the soil tend to smear rather than to cut cleanly (see photographs, plate 3).

2) The stockless soil is more susceptible to capping, that is, to blockage of the pore spaces under the action of rain with consequent ponding of the surface water leading to flash run-off.

In 1961 Rothamsted Experimental Station had included Haughley in a survey of certain physical attributes of soil which are relevant to this study. These are recorded in the following table (results reported by Williams 1961).

Data recorded are:

(A) Mechanical composition of the three field systems

Field type	Stone 6mm	Coarse Sand 2-0.2 mm	Fine Sand 0.2-0.02mm	Silt 0.02-0.002mm	Clay 0.002mm
Organic	2.1	25.4	33.8	8.7	20.0
Mixed	1.6	26.4	23.5	11.0	26.3
Stockless	3.4	27.0	33.5	8.3	19.3

(B) Physical measurements of the three field systems

Field type	Density	Apparent Density g/ml	% Water Holding Capacity	I/Ws	I/ds	I/ms	B/s
Organic	2.46	1.25	55.8	7.6	19.7	64.2	9.97
Mixed	2.42	1.25	66.2	4.6	21.2	60.8	5.30
Stockless	2.51	1.34	47.3	39.2	21.3	65.5	8.00

The outstanding differences are the greater density, lower water holding capacity, and markedly greater susceptibility to slaking by water (I/ws). The latter measurement relates to the stability of the soil aggregates when wetted. As pointed out by Williams (1970) I/ws values below 8.3 show the soil to be stable, that is the aggregations will not readily break up on wetting cf. the organic soils. In contrast, soil with an I/ws of more than 41.7 are considered unstable, and those with values of 46.9 to be very unstable, that is soils in which "slaking" releases individual particles blocking the pore spaces.

The high I/ws value for the stockless field correlate with its lower values both for organic matter and clay and silt and higher values for gravel and coarse sand cf. William (1970). Thus it would seem that the higher value of organic matter recorded for the organic and the stockless soils show a real positive effect in the maintenance of stable structure at the particle level, thus allowing freer percolation of the water through the soil.

At first sight it might appear that this difference in free drainage could account for the main differences in losses of geochemicals to ground water recorded in the lysimeter experiments in that excess slaking could cause blockage of the pore space leading to: 1) ponding of surface water and losses from the lysimeter by overflow, and/or 2) leading to less efficient percolation of water through the soil mass, and thus a reduction in contact of the water with the soil. The construction of the lysimeter in part ruled out the first, but the second may well be a real factor affecting the lysimeter results.

Nevertheless, this does not explain the significantly higher levels of total geochemicals in the organic soil. In fact, it would seem that as the effect indicated by the lysimeter experiments is a higher mobility of geochemicals in the organic soil and that from the slaking measurements a lower relative percolation of water through the stockless soil, that the latter not former should be richer in geochemicals.

It must however be borne in mind that Haughley is situated in the driest area of the United Kingdom where the precipitation evaporation balance is negative. For much of the growing season the main pedogenic process is likely to be evaporation. Evaporation accompanied by enrichment of the upper layers with geochemicals, via the capillary water brought up from below.

The instability of the stockless soil would of course have a similar effect in whichever direction the water was moving through the profile. Thus the higher levels of Ca, Mg and K could be related to more efficient transport of capillary water upwards through the soil profile over the 32 years of the main experiment.

In the light of these observations, a possible explanation for the differences found between the greenhouse and the field experiment may be advanced.

Grown under greenhouse conditions the plants were not subject to the same interplay of environmental stress as those growing in the field. This is especially true of water stress conditions, for the greenhouse plants were kept irrigated throughout the whole experimental period. It may well be that under field conditions the major factors affecting the growth of the barley are water stress or some other environmental factor which could effectively mask any differences due to differences in geochemical supply. This could account for the fact that more differences related to the treatments were found under greenhouse conditions than in the field.

In conclusion some further references may be made to the differences found between the absolute and the mean (computed) results.

The whole basis of agricultural comparisons between cereal crops and between cereal crop systems relates to grain yield. The reason is evident, because it is the grain that is required by the farmer.

It could be argued that an absolute maximum value (whether related to vegetative or reproductive yield) could be interpretated as an integration of the whole growth phenology of the plant up to that stage. Yet in both the field and greenhouse experiments, differences revealed on the basis of maximum values were not upheld when the complete growth phenomena were taken into account. This was especially true in the case of the comparison made using the Hughes programme.
It had been hoped to be able to discuss the results obtained in the study with the author of the programme. This was impossible owing to the fact that he died in 1972.

It is felt that the relationship between the mean and absolute performance deserves further investigation.

The very tentative conclusions drawn from the work are as follows:

32 years of differing management of the three farm systems at Haughley have produced:

1) Differences in the total geochemistry of the system which may be interpreted on the basis of changes in the physical structure of the soils.

2) Differences in the available geochemistry of the three systems, which may be interpreted on the basis of long term application of organic manures maintaining both high levels of nitrogen compounds in the soil and a larger exchangeable fraction of the geochemicals.

3) Differences in the "mobility" of the geochemicals potentially available both to the crop and to loss of gravitational water.

4) The complete lack of potential nitrogen fixation by soil microorganisms under field conditions.

5) The differences recorded between the soil were not upheld by the phytometer experiments. In all cases where significant differences were found, the level of significance was low. Yet in most of the cases where significances differences were recorded, it was the organic crop/soil system which gave the highest value of performance and/or of flux of geochemicals into the crop.

In the light of the data and these tentative conclusions, the whole rationale of the work can be discussed.

The limitation of such a broad based screening operation are obvious. In hindsight it is easy to ask "why did I not concentrate on the nitrogenous compounds in exclusion to the rest?" The answer would be that other factors like the increased levels of certain total geochemicals would have been missed and the possible interaction with water stress overlooked. The work, crude as it is, and the conclusions, tentative as they are do indicate the following to be spheres worthy of further investigation.

Intensive study allowing the assessment:

1) Correlation between the physical characteristics of the soil, especially I/ws and water holding capacity with the geochemicals of the soil farm systems.

2) Detailed study of the whole range of "exchangeable" (cf. available) geochemicals using a range of extractants on the three farm systems.

3) Simple leaching experiments comparing the mobility of the ions in the soil types.

4) Comparison of the total geochemistry of similar soils under more permanent vegetation, to ascertain the effect, if any, of reducing capillary enrichment of the surface layers by shading.

5) Expansion of the lysimeter experiments using whole field systems and monitoring the field drain outflow. This would allow comparison of the instability effect with the throughput of geochemicals in relations to time, manure/fertilizer application and rainfall.

6) Comparison of the organic and stockless fields, each enriched with increasing amounts of geochemicals, in order to find the levels of application which evoked a eutrophication effect in either the ground water or the crop system.

SECTION V.

APPENDIX.

A) Barley and Fertilizers A Brief Synopsis of Earlier Work

THE USE OF BARLEY AS PHYTOMETER

Allison (1966) in his work with nitrogen fertilizers, reported that, "Nitrogen fertilizer is commonly the most important element applied to the soil for maintained good yield." Barley varieties have been tested by many investigators. Foot, et. al. (1953) using Hannchen Barley as phytometer, reported that applicatinn of nitrogen fertilizers as a foliar spray produced a significant increase in the yield.

In the United States many experiments have been carried out to improve the yield of farm crops. Barley growth variations has been related to their nutrient contents. Carlson et al. (1958) reported that nitrogen fertilizer increased barley yields, especially when the nitrogen was applied at sowing time. Bullen and Lessels (1957) obtained a number increase in the yield of barley. In other work, Resinauer and Dickson (1961) showed that the nitrogen content of the grains had increased as a result of nitrogen applications.

Recently many experiments have come out to establish correlations between the yields of barley treated with alternative nitrogen fertilizers. Devine and Holmes (1963) obtained similar mean yields of spring barley from the broadcasting of either ammonium sulphate or ammonium mitrate. A summary of recent work with nitrogen has been published by Cook (1964) in which he calculated that there were no instances of ammonium salts being markedly superior to nitrates, unless the nitrate adversely affected germination.

Field experiments have been made to test the values of nitrogen for increasing the yield of barley, wheat and oats. All results have shown that those crops differ markedly in their requirements for applied nitrogen to give maximum economical yields (Lessells and Webbers, 1965).

The increase in crop dry matter was one of various parameters used to test the effects of nitrogen fertilizer. Gasser et. al. (1967) found that a greater yield dry matter was produced by a nitrogen compound (Nitrate-Nitrogen) in the later stages of the growth. In other experiments, Widdowson and Penny (1970) reported that application of nitrogen to barley, wheat and kale gave increased yields wherever applications were made.

Phosphorus

Much work has been carried out covering the use of phosphotic fertilizers either added by themselves or in combination with nitrogen or potassium.

For example, Crowther (1945) obtained mean yield increases in barley as high as about 6 cwt/acre of grains from 54 units per acre of P_2O_5, while Cooke and Widdowson (1956) reported increases of up to 4.7 cwt/acre when 45 units/acre of P_2O_5 were drilled with the seeds.

In other investigations, Hooper(1960) working in southern England, showed that phosphate had only a small effect on yield and 29 units/acre of P_2O_5 was on average the most economical rate of application. The effect of phosphorus on crop fresh weights has been long realised. Simpson et al (1959) reported that shoot yield was stimulated by dressing of super-phosphate up to 2 cwt/acre of P_2O_5.

Phosphorus in Combination with Nitrogen

Work has been reported from Dakota by Carlson et al (1958), where barley yield increased from nitrogen fertilizers and when nitrogen and phosphorus were added together, the yields were higher than when either was used alone.

Similar investigations have been obtained in other parts of the world. In Northern India, Sen (1961) and Relwani (1961) obtained higher yields by adding nitrogen and phosphorus to two barley varieties.

Fertilizer application during the early stages of the growing season have resulted in marked increases in the yield of many kinds of cereals. Warder et. al (1963) showed that phosphorus in combination with nitrogen fertilizers increased winter root weight, and protein determinations also emphasized this increase. They showed that quite low levels of nitrogen in combination with phosphorus fertilizer, increased the protein content of the grain more than was expected. On testing varying rates of nitrogen and phosphorus applied to spring barley plots, Atkins et al.(1955) reported that increases in the grain yield through combined nitrogen and phosphorus application were unusually high.

Phosphorus in Combination with Potassium

In experiments with phosphorus and potassium, Hunter (1962) reported that the influence of these two elements on grain quality was small, and another report (Stroble, 1960) showed that phosphorus and potassium may reduce the nitrogen content of barley.

Between 1964-66 N.A.A.S. reports on the effects of applying three levels of phosphorus and potassium (0,30 and 60 P_2O_5/acre and 0,30 and 60 K_2O/ acre) showed a larger increase of spring barley yield than when a high application of P_2O_5 was added alone.

Nitrogen, Phosphorus and Potassium Applications

In order to improve the yield of many cereals, experiments have been carried out testing nitrogen in combination with phosphorus and potassium. William et al (1963) showed a good response to phosphorus and potassium. Other investigations have been made in Nigeria. Wari (1965) showed that treatments gave greater yield in the first season, and suggested that nitrogen, phosphorus and potassium fertilizers should be applied during every cropping season.

These kinds of investigations have been continued all over the world, aimed at increasing crop production (Stroble, 1960; Hunter, 1962- Gately, 1968- Macloed et al.,1969).

As a result of these experiments, great effects have been established with relation to crop performance- this may be known as the "response".

B) GROWTH PHYSIOLOGY ANALYSIS

1. Estimation of Leaf Area

This estimation is basic to many investigations in plant physiology, and leaf area could be used more often than it is as an index of growth for intermediate stages in agronomic experiments both in pot culture and under field conditions.

The method used in this study is after Blade(1943) modified by Blackman and Wilson (1951).

Procedure

After separation of the leaves from the stems, the leaves were placed between two sheets of glass, illuminated from below, and then the outlines were drawn on paper of uniform thickness.

The leaf outlines on the paper were cut out with a pair of scissors and themselves weighed along with a square of paper from the same sheet, measuring 100 sq. cn. from these weights, the ratio of the area of fresh leaf per gram dry weight was calculated, and this factor was applied to the dry weight of the whole leaf samples to estimate the total leaf area.

2. Determination of Dry Weight

After plants were dug or pulled up, adhering soil particles were removed by repeated careful washing in tap followed by distilled water. Samples were then placed in separate labelled bags and dried in a hot air oven at 80^{o}C for 2 days until constant weight was attained.

The samples were removed from the oven and placed in a dessicator until cool, then weighed accurately to at least three places of decimals. The weights are recorded in milligram per plant.

C) Subsidiary addition of the statistical analysis (Philips 1969)

A. Fitting the growth curves.

If plants have dry weights W1, W2,....Wn are harvested at times t1, t2,.....tn, a cubic regression equation of LogW against t is fitted. That is, it is assumed that at each time of harvesting, the observed value of Log W is given by

$$\text{LogW} = a+bt+ct^2+dt^3+\varepsilon \qquad (1)$$

where the first four terms regressed the "true" curve, and represents the error of observation. These errors are assumed to be independently normally distributed with mean O and the same variance

It is convenient to write the equation as

$$\text{LogW} = a_1+b_1(\text{lin})+c_1(\text{quad})+d_1(\text{cub})+\varepsilon \qquad (2)$$

where

$$\text{lin} = t+A \qquad A = -\frac{1}{n}\Sigma t$$

$$\text{qud} = t^2+Bt+C \quad \text{and} \quad B = \frac{\Sigma t^3+A\Sigma t^2}{\Sigma t^2+A\Sigma t}$$

$$\text{cub} = t^3+Dt^2+Et+F \qquad C = \frac{1}{n}(\Sigma t^2+B\Sigma t)$$

$$D = \frac{\Sigma t^5+B\Sigma t^4+C\Sigma t^3}{t^4+B\ t^3+C\ t^2}$$

$$E = \frac{\Sigma t^4+A\,\Sigma t^3+D(\Sigma t^3+A\,\Sigma t^2)}{t^2+A\ t}$$

$$F = -\frac{1}{n}(\Sigma t^3+D\Sigma t^2+E\Sigma t).$$

The coefficients a_1, b_1, c_1, d_1, are estimated by "Least square", i.e. are chosen to make the sum of the squares of discrepancies between observed and fitted values as small as possible, giving

$$\hat{a}_1 = \frac{1}{n} \text{ (log W)} \qquad \sqrt{\frac{\sigma^2}{n}} \qquad (3)$$

$$b_1 = \frac{\Sigma(\text{lin})(\log W)}{\Sigma(\text{lin})^2} \qquad \sqrt{\frac{\sigma^2}{(\text{lin})^2}} \qquad (4)$$

$$c_1 = \frac{\Sigma(\text{quad})(\log W)}{\Sigma(\text{quad})^2} \quad \text{with standard deviations} \quad \sqrt{\frac{\sigma^2}{(\text{quad})^2}} \qquad (5)$$

$$d_1 = \frac{\Sigma(\text{Cub})(\log W)}{\Sigma(\text{Cub})^2} \qquad \sqrt{\frac{\sigma^2}{(\text{cub})^2}} \qquad (6)$$

The variance analysis table is:

Source	d.f.	S.S.	D.F.
Linear	1	$\hat{b}_1^2 \quad (\text{lin})^2$	1
Quadratic	1	$\hat{c}_1^2 \quad (\text{quad})^2$	1
Cubic	1	$\hat{d}_1^2 \quad (\text{cub})^2$	1
Residual	n-4	by subtraction	n-4
Total	n-1	$\Sigma(\log W - a.)^2$	n-1

In this method if a number of plants harvested at any time were no more than one plant, that means the residual S.S. is further broken down into between and within harvesting time.

To estimate the variance σ^2 of the errors you should apply this formula:

$$\hat{\sigma}^2 = \text{residual mean square} = \frac{\text{residual S.S.}}{n-4}$$

and this is substituted into (3), (4), (5) and (6) to give the errors. From that the coefficients could be estimated.

To compare equation (1) and (2) you will get:

$$d = d_1$$
$$c = c_1 d_1 D$$
$$b = b_1 C_1 B + d_1 E$$
$$a = a_1 + b_1 A + C_1 C + d_1 F$$

From here standard errors could be joined to the estimates $\hat{a}$, $\hat{b}$, $\hat{c}$, $\hat{d}$ of a, b, c, d, Using the fact that $\hat{a}_1$, $\hat{b}_1$, $\hat{c}_1$, $\hat{d}_1$ are not correlated.

From equation (2) the variance of any fitted value of log W is equal:

$$\sigma^2 \left[\frac{1}{n} + \frac{(\text{lin})^2}{\Sigma(\text{lin})^2} + \frac{(\text{quad})^2}{\Sigma(\text{quad})^2} + \frac{(\text{cub})^2}{\Sigma(\text{cub})^2}\right] \qquad (7)$$

To put back in place the σ^2 by its estimate and take the square root gives the S.E. of the fitted log W values. The same considerations apply to fitting a cubic curve to log A data.

B. Fiducial Limits

To characterize between several fiducial limits you have to take two important factors in to account.

(1) For any fixed value of t, it would include the point on the "true" curve at that value of t on 95% of the occasions. This could by found out by multiplying the S.E. of fitted value at that time by the two-sided 5% level of significance of student's t distribution on n-4 degree of freedom, "$t_{n-4}(05)$".

As observation number (n) increases, the S.E. will decrease and the value of t_{n-4} (.05) will also decrease towards its limit of 1.96, thus narrowing the fiducial limits.

(2) For any fixed value of t the limits within which, with probability 0.95 a single further observation would lie.

This could be obtained by adding the square of the S.E. of the fitted value to the residual mean square $\hat{\sigma}^2$ and taking the square root and multiplying by $t_{n-4}(0.5)$. If "the mean of M further observations" is substituted for " a single further observation" in the above statement, $\frac{\hat{\sigma}^2}{m}$ is added instead of $\hat{\sigma}^2$.

C. Derived functions of the fitted curves

(a) Relative growth rate (R.G.R.) = $\frac{1}{W}\frac{dW}{dT} = \frac{d(\log W)}{dT} =$

$b_1 + C_1\,(2t + B) + d_1\,(3t^2+2Dt+E)$

The variance of fitted value is:

$$\sigma^2\left[\frac{1}{\Sigma(1in)^2} + \frac{(2t=B)^2}{\Sigma(qad)^2} + \frac{(3t^2+2Dt+E)^2}{\Sigma(cub)^2}\right]$$

∴ S.E. and kind (a) Fiducial limits can be constructed as before.

(b) Leaf area ratio (L.A.R.) = antilog (logA-LogW)

The variance of fitted value is:

$$(\sigma^2 A = \sigma^2 A - 2C)\left[\frac{1}{n} + \frac{(1in)^2}{\Sigma(1in)^2} + \frac{(qad)^2}{\Sigma(qad)^2} + \frac{(cub)^2}{\Sigma(cub)^2}\right](\text{fitted } \tfrac{A}{W})^2$$

Where σ^2 and $\sigma^2 W$ are estimated as the residual mean squares for log A and log W, C = co-variance of the measurements of log A and log W, estimated as $\hat{C}$, the residual sum of products in the analysis of variance, divided by n-4. Normally, C is positive.

To calculate fiducial limits for Log A - log W use the variance:

$$(\sigma^2 A + \sigma^2 W - 2C)\left[\frac{1}{n} + \frac{(1in)^2}{\Sigma(1in)^2} + \frac{(qad)^2}{\Sigma(qad)^2} + \frac{(cub)^2}{\Sigma(cub)^2}\right]$$

and take their antilogs to get corresponding fiducial limits for $\frac{A}{W}$, and hence used in the computer programme used. But it does yield an interval slightly unsymmetrical about the fitted value.

(c) Net Assimilation Rate (NAR) = $\frac{1}{A}\frac{dW}{dT} = \frac{1}{W}\frac{dW}{dT} - \frac{A}{W}$

The Variance of fitted value is:

$$\frac{1}{\left(\frac{\text{Fitted}-A}{W}\right)^2}\left\{\sigma^2 W\left[\frac{1}{\Sigma(\text{lin})^2}+\frac{(2t+B)^2}{\Sigma(\text{qad})^2}+\frac{(3t^2+2Dt+E)^2}{\Sigma(\text{cub})^2}\right]+\right.$$

$$(\sigma^2 A+\sigma^2 W-2C)\left[\frac{1}{n}+\frac{(\text{lin})^2}{\Sigma(\text{lin})^2}\right.$$

$$\left.+\frac{(\text{qud})^2}{\Sigma(\text{qad})^2}+\frac{(\text{cub})^2}{\Sigma(\text{cub})^2}\right]\left(\text{fitted }\frac{d\log W}{dt}\right)^2$$

$$-2(C-\sigma^2 W)\left[\frac{\text{lin}}{\Sigma(\text{lin})^2}+\frac{(2t+B)(\text{qud})}{\Sigma(\text{qud})^2}\right.$$

$$\left.\left.+\frac{(3t^2+2Dt+E)(\text{cub})}{\Sigma(\text{cub})^2}\right]\left(\text{fitted }\frac{d\log W}{dt}\right)\right\}$$

D) THE GREENHOUSE

In the experiments in the greenhouse (growth cabinet) all plants were subjected to identical conditions throughout the experimental period.

It was, however, impossible to control temperature, light and humidity over the entire length of the experimental period within narrow limits. There is some variations in these factors yet in the growth cabinet, as far as possible, all plants were exposed to the same variations.

To minimize the effects of this variability, all plant types were grown in 6 X 6 Latin square arrangements as illustrated in plate 2 .

In general, conditions in the growth cabinet were:

1) Light - 8 Phillips 400 watt mercury vapour horticultural lamps were used to give a period of 16-18 hours.
2) Maximum day temperature at 80°F
3) Minimum night temperature at 75°F
4) Relative humidity up to 90%.

E) LYSIMETER CONSTRUCTIONS

The experiment was set up in the first week of March 1972 at Haughley farm. The types used were classified as the field-in (Helmut et al., 1940). (This consists of a container which has vertical walls, an open top, and a bottom that provides for percolation. The container was filled with soil that has been removed from its original location. The top was completely covered with soil so that the ground was level with the surrounding soil. The construction permits natural run-off and eliminates the border effect resulting from the raised area along the rim of the lysimeter).

Lysimeter Types

Two types of lysimeters have been used:

(1) Deep Lysimeters
(2) Shallow Lysimeters

(1) Deep Lysimeters

This was constructed out of commercial plastic containers (dustbins) (see Plate 4), 10.37 m in diameter, 0.29 m at the top and 0.22 m at the base (area = 0.37 x 0.29 = 0.081 sq. m = 0.000266 ha). This container has sloping walls and open top.

In each one there is a basal aperture for drainage. This drain hole is connected to a plastic tube draining the run-off water to the percolating reservoirs, for which plastic buckets were used. The plastic buckets were covered with black polythene sheets to prevent the growth of microorganisms.

(2) Shallow Lysimeters

This type of lysimeter was constructed from polythene sheets. The sheets covered an area of 1.2 m x 1.2 m to a depth of 2.5m (area = 1.2X1.2 = 1.14 sq m = 0.0003855 ha).

The bottoms of the shallow lysimeter were shaped so that there was a slope towards the middle of each. See plate 5 . These slopes made a channel along which water flowed and from which waters could be easily collected. To facilitate this, a layer of gravel was placed between the soil and lysimeter bottom.

All lysimeters were filled with soil that was originally removed from the location in which the lysimeter had been placed. This was placed in the lysimeter in its original orientation, with as little disturbance as possible.

The tops of the side walls in all the lysimeters were completely covered with the soil so that the top of the lysimeter was level with the surrounding soil, this permitting natural run-off or percolation.

The experiment was located on the organic field, mixed field, and in the stockless field. For details see map Fig. 1.

In the organic field 6 lysimeters (3 deep and 3 shallow) were arranged in two rows in a plot 10.5 m long and 5.5 m wide. 6 others (3 deeps and 3 shallows) were also used in the mixed field in a plot 18.5 m long and 3 m wide.

The stockless field was set up with 6 deep and 6 shallow lysimeters in rows on a plot 32 m X 3 m. The pattern was repeated in this field at a higher level of fertilizers (7.2 cwt/acre N.P.K.). Barley (var. JULIA) was used and was planted in the lysimeters. Half of the lysimeters were fallow (controlled).

At both ends of each row of the different lysimeters in the fields, barley seeds were planted between the lysimeter spacings. These planted seeds were sown in the same manner as in the lysimeters.

F) SOIL SURVEY

Report was prepared by Rodney Williams in 1948. The area was surveyed by the normal methods adopted by the soil survey.

Four local phases of the Beccles Series (Corbett and Tatler, 1970), were distinguished and divided into phases.

Phase 1

It is derived from a calcareous clay. The upper horizon consists of 23 cn. of olive-brown sandy clay-loam, sharply distinguished from a variable thickness (13-46 cn) of bright yellow-brown sandy clay which contains no chalk particles. This horizon has occasional brown on grey mottlings on cloudings. Below this, horizon 3 consists of very pale yellow-brown clay intensely mottled with pale grey or white. While this is probably due to the parent material containing a very high proportion of chalk, there is the possibility that it may be partly caused by intense gleying which could produce a whitish clay with yellow-brown markings. Large and small chalk particles occur in this layer and small black MnO_2 concentrations are occasionally found.

The zone has a small prismatic structure. The colour of the second layer is typically bright, but duller colours do occur.

Phase 2

It is the most extensive, occupying about half the area of the farm. It forms a west to east belt across the farm, north of the buildings with a prolongation south.

The parent material is derived from a calcareous clay, but contains a much greater proportion of clay and less fine sand than that of Phase 1. The surface soil is about 23 cn.

thick, grey brown in colour and with a sandy clay-loam texture. It is sharply distinguished from the second layer which consists of 26 cn. or more of dull greyish-yellow brown clay mottled with grey.

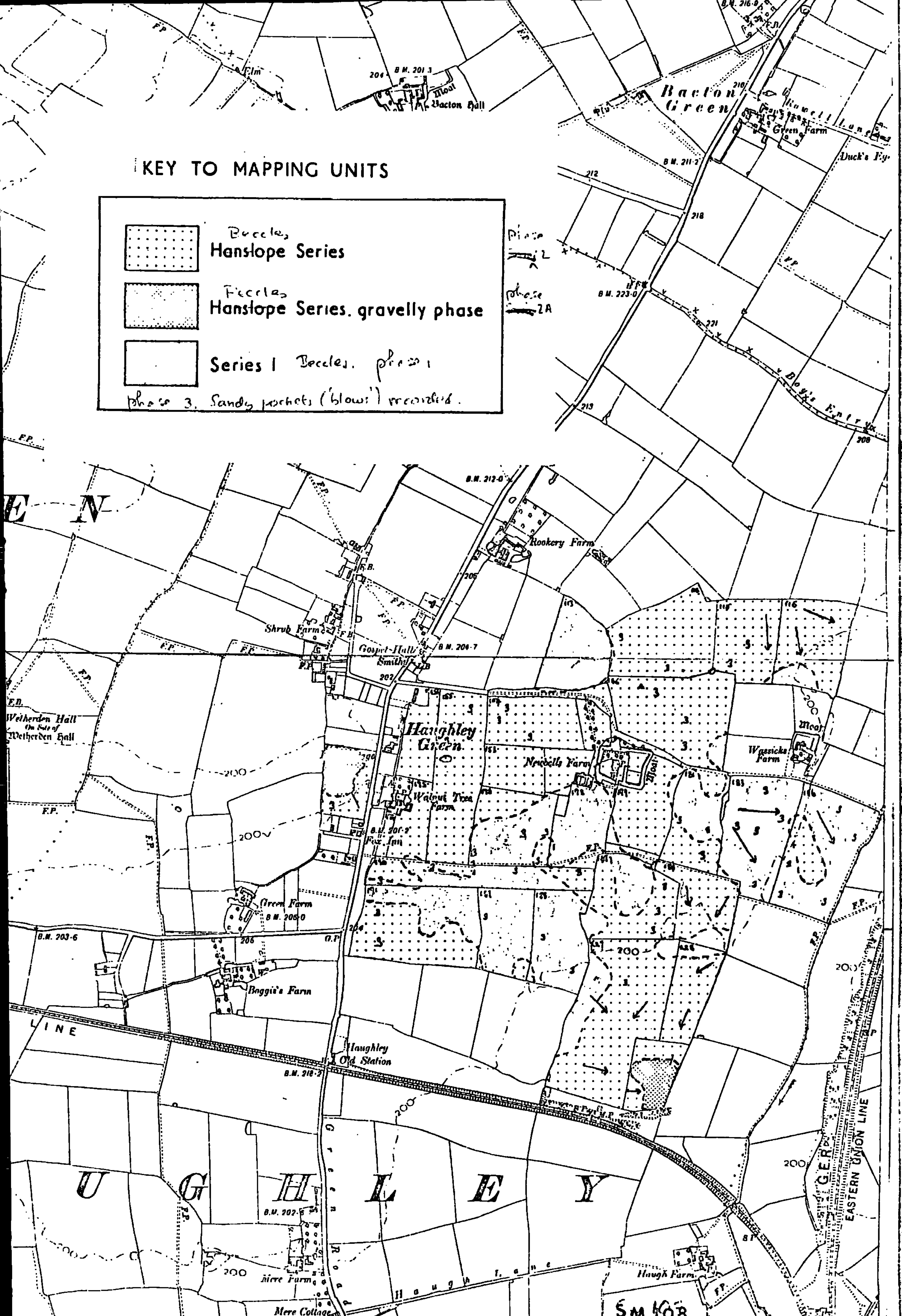
Neither of these layers contains chalk particles, although they are calcareous. Below this layer, at 51 cn. olive-brown clay occurs with grey and brown mottling, and containing occasional MnO_2 concentrations. Chalk particles are abundant.

Phase 3

This phase occurs sporadically over the whole farm and is derived from a calcareous sand. The upper is similar to those of Phase 1 and 2, containing about 23 cn olive brown, slightly sandy clay-loam. A sharp boundary divides this from the second layer, a sandy loam, which is always wet and often waterlogged below 2' - 2'6". Usually the colour is bright yellow-brown, but it may have an orange tinge, or, where it is waterlogged, it may be a duller greyish-brown.

In all cases it is slightly mottled with greyish-yellow or grey chalky clays, similar to that of layer three or Phase 1, is found at variable depths, but generally sand is found to the full extend of the auger used.

See the geobiological map.


KEY TO MAPPING UNITS
Beccles
Hanslope Series
phase 2
Beccles
Hanslope Series. gravelly phase
phase 2A
Series I
Beccles. phase 1
phase 3. Sandy pockets ('blows') recorded.
Bacton Hall
Moat
Elm
Bacton Green
Green Farm
Duck's Ey
Rookery Farm
Shrub Farm
Gospel Hall
Smithy
Wetherden Hall
Site of Wetherden Hall
Haughley Green
Newbells Farm
Moat
Wassicks Farm
Walnut Tree Farm
Fox Inn
Green Farm
Baggie's Farm
LINE
Haughley Old Station
Haugh Farm
Mere Farm
Mere Cottage
Green Road
Haugh Lane
G.E.R.
EASTERN UNION LINE
U G H L E Y

G) CHEMICAL ANALYSIS

1. Nitrate-Nitrogen Determination of plant materials.

This method is based on the nitration of phenol- 2:4 disulphonic acid by nitrates in plant materials to 6- nitro-phenol - 2:4 disulphonic acid, which gives yellow colour as result of alkaline condition. (The intensity of the yellow colouration is proportional to the concentration of the nitrates in the sample).

This method has been described by Johnson and Ulrich (1950).

Reagents

30% Hydrogen peroxide (H_2O_2) micro chemical grade contains less than 9 p.p.m. nitrate-nitrogen, below in acidity.

25% phenoldisulphonic acid

1:1 Ammonia solution (Analar)

Potassium Nitrate KNO_3 (Analar)

Calcium Carbonate $CaCO_3$

Procedure

Extraction 100 milligrams samples of ground dried plant materials were placed in 100 ml. conical flasks. 30 ml.of distilled water was added and placed in an automatic shaker for 15 minutes. Filter through No. 42 paper.

Digestion 10 ml. Aliquot were taken into evaporating dishes, 2 ml. of suspension calcium carbonate (1 gram to 200 ml. distilled water) to neutrilize the acids originating from the reagents) followed by 1 ml. of hydrogen peroxide (to destroy the organic matter). Cover the dishes and start to digest on a steaming water bath for 2 hours. Remove the covers and continue evaporation to dryness. This takes about 30 minutes.

<u>Nitration</u> To the cold residue add 2 ml. of phenol disulphonic acid rapidly, mix the reagent with the residue using a glass rod. Wait for 10 minutes and then add carefully 20 ml. 1:1 ammonium solution. Make the solution up to 50 ml. with distilled water.

Read the intensity of the yellow colour in the specrophotometer using wave length of 420 um.

A blank should be prepared in the same way without plant materials.

<u>Standard Nitrate-Nitrogen</u> Prepare standard solution using potassium nitrate. Dissolve 7.22 grams of KNO_3 in distilled water and make it up to 1 liter. Dilute 5 ml. of the stock standard to 1 liter with distilled water. This solution contains 5 micrograms of nitrogen at nitrate-nitrogen per ml.

A calibration curve was prepared using different dilutions of the standard and plot out the spectrophotometric readings against the standard concentration. See Figure 51 and Table A1.

N.B. Before determination of the nitrate-nitrogen, chloride should be first estimated. If the chloride concentration is found to be more than 1.0% the interference will occur. Eliminate the chloride in the sample by the addition of silver nitrate.

Table A1

Calibration data for nitrate-nitrogen (phenoldisulphonic acid method). Standard prepared from KNO_3. Blank = 0.3 Absorption of colour determined at 420 u m.

Concentration µg/ml	Reading	Concentration µg/ml	Reading
0.092	0.245	0.566	1.68
0.250	0.710	0.750	1.48
0.372	0.900	0.930	2.70

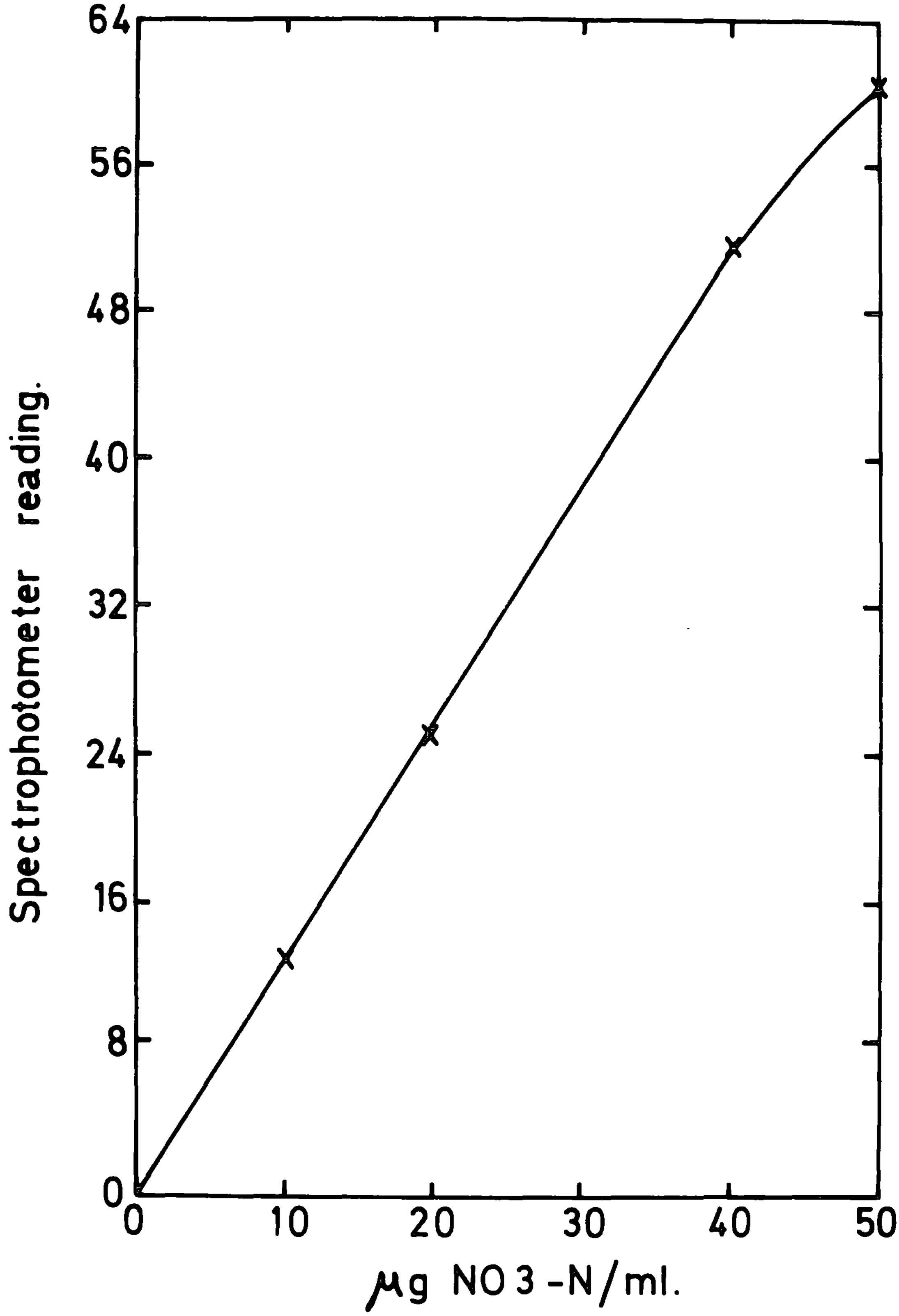


FIG. 51 Calibration Curve of Available Nitrate - Nitrogen. Each point mean of three; Full details table.A1

2. Determination of Nitrate in Water

This method depends upon the reaction between 2-6 xylenol and nitrate, takes place in sulphuric acid medium in the presence of ammonium chloride. Before measuring the nitrates, nitrites should be distroyed by sulphamic acid.

The method as used was discribed by Montgomery and Dymock (1962).

Reagents

1) Sulphuric acid. Mix 455 ml. of M.A.R. sulphuric acids, (98 to 100%) with 171 ml. of distilled water. (The acid should be 80.5 - 83.3% w/w, sp. gr. 1.733 - 1.762 at 20°C). Cool at below 10°C.

2) Ammonium chloride solution. 24 grams of Analar ammonium chloride dissolved in 100 ml. distilled water.

3) 2 - 6 xylenol. 0.122 grams of 2-6 xylenol dissolved in 50 ml. of Analar acitic acids then add this solution to Ammonium chloride.

4) Sulphamic Acid Papers. Cut a disc of 5.5 cn. Whatman No. 1 filter papers into 16 equal segments. Soak in water solution of 5 grams sulphamic acid (Analar) in 10 ml. distilled water. Allow the pieces to dry on a watch glass and store in stoppered bottle.

5) Standard Nitrate-Nitrogen solution. 7.22 gram potassium Nitrate (Analar) dissolved in 1 liter. This contains 5.0 micrograms per ml. if 5.0 ml of the stock solution diluted to 1 L.

Procedure

Add the paper containing sulphamic acid to about 20 ml of the sample and stir. Set aside for at least 5 minutes. Add

8 ml. of cooled Sulphuric acid to 50 ml. beaker (The addition of the acid should be done by pipette), Without delay add 1 ml. of the sample to the bulk of the acid followed by 1 ml. of 2-6 xylenol reagent solution and mix gently using a glass rod. Wait about 5 minutes and add 15 ml. of distilled water. Set aside for 15 minutes. Measure the optical density using Parkin Elmer 402 spectrophotometer at 310 m u in Silica cells against reagent blank solution which has been prepared in the same way in the same conditions without water sample.

Calibration Curve

Dilutions of standard solution from 0 - 2 micrograms per ml. have been prepared and then followed by the procedure above. Readings are plotted against the concentrations. For details see Table A2 and Figure 52.

Table A2

Calibration data for nitrate- nitrogen determination of water samples. Standard prepared from potassium nitrate (Analar). Blank = 0.07. Optical density was measured by P.E. spectrophotometer at 310 m µ.

Concentration µg/ml.	Reading	Concentration µg/ml.	Reading
0.2	0.25	1.2	1.50
0.4	0.50	1.6	2.0
0.8	0.93	2.0	2.65

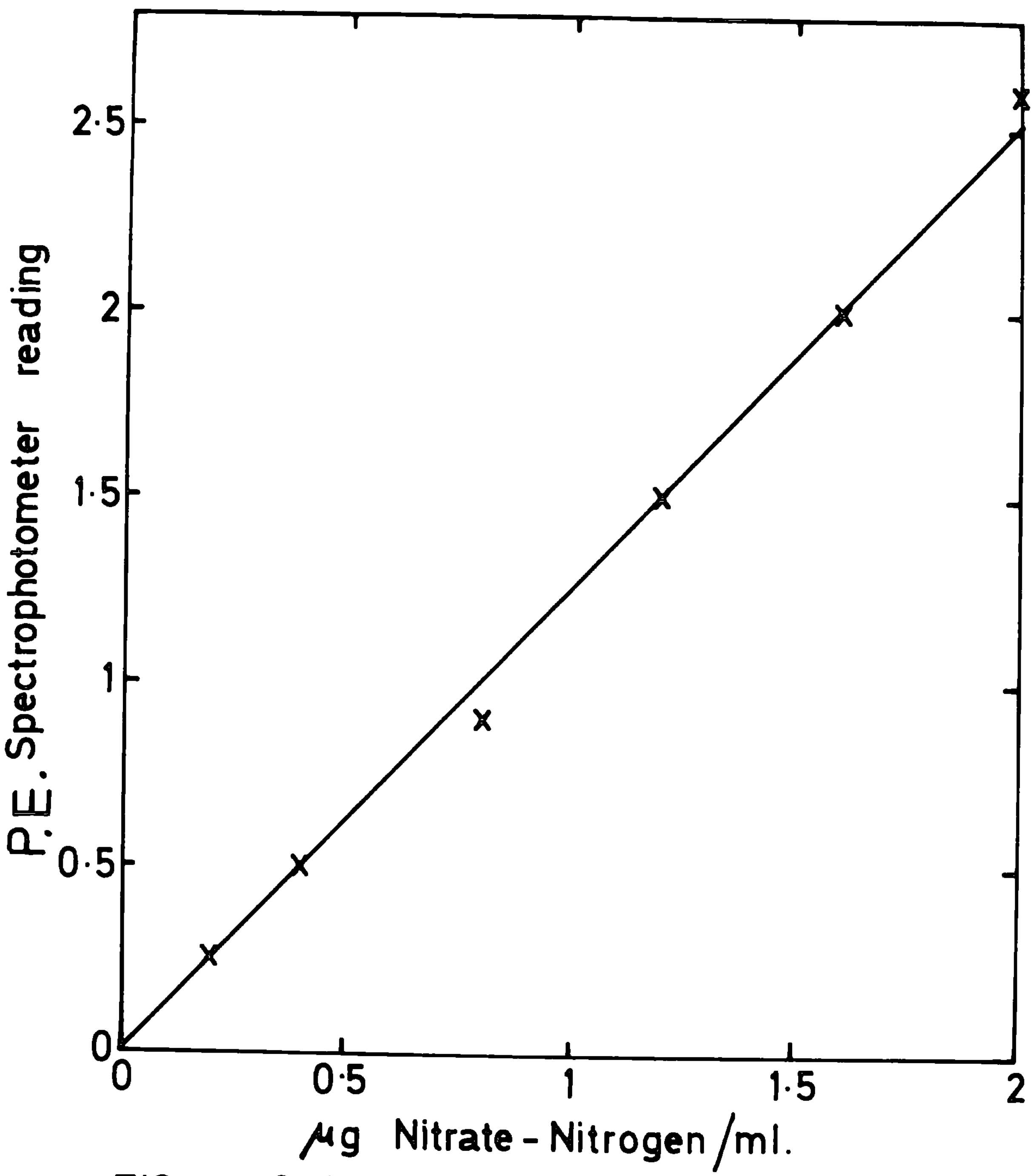


FIG. 52 Calibration Curve of Nitrate-Nitrogen.
Each point mean of three; Full details table A2

3. Determination of Available Phosphorus in Soil

In this method phosphorus is extracted from soil with use of 0.5M Sodium bicarbonate at about 8.5 of PH. The method used is described by Olsen et al (1954).

Reagents

1) Sodium bicarbonate 0.5M: PH of the solution should be adjusted at 8.5 with 1M sodium hydroxide.

2) Carbon black was omitted because of its containing a lot of phosphorus.

3) Ammonium molybdate($(NH4)_6\ MO_7\ O_{24}\ .4H_2O$). 15.0 grams dissolved in 300 ml of distilled water, filter the mixture if necessary, allow to cool, add 342 ml of concentrated hydrochloric acid (HCl) gradually with mixing. Dilute the lot to 1000 ml with distilled water.

4) Stannous chloride ($Sn\ Cl_2\ 2H_2O$) Dissolve 10.0 grams of stannous chloride in 25 ml of concentrated hydrochloric acid. (Prepare fresh every time).

5) Stannous chloride solution. Dilute 0.5 ml of stannous chloride with 66 ml of distilled water (prepared every time).

6) Standard solution. 0.4393 grams monobasic potassium phosphate (A.N.) (KH_2PO_4) dissolved in 500 ml of distilled water in a 1-liter volumetric flask. Dilute the solution to liter. 20 ml of this solution diluted to 1 liter. 1 ml= 2µg Phosphorus.

Procedure

5 grams of air-dried soil taken up with 100 ml of the extracting solution (extracting solution prepared by adding 12 ml of concentrated H_2SO_4 and 73 ml of concentrated HCl to 16 liters of distilled water, (This solution is approximately

0.05NHCl and 0.025 H_2SO_4) into 25o ml Erlenmyer flask. Shake for 30 minutes with a suitable shaker. Filter the suspension using No. 40 papers.

Aliquot taken (it depends upon the phosphorus concentration) into 25 ml volumetric flasks. Slowly add 5 ml of Ammonium molybdate, shake the solution gently to mix the content, wash down the neck of the flask and dilute the lot to 22 ml with distilled water. Add 1 ml diluted stannous chloride and the solution is made up to volume.

Blank should be done in the same way without soil sample. Wait 10 minutes and measure the transmittance of the solution in the Spectrophotometer at 660 mμ.

Calibration Curve

Aliquot of dilute phosphorus contains from 2 Ng to 50μg/ml phosphorus into volumetric flasks add 5 ml of Na_HCO_3 extracting solution and follow the procedure to develop the colour.

Results are shown in Table A3 and illustrated in graph (see Figure 53).

Table A3

Calibration Data for Available Phosphorus using Sodium Bicarbonate method (Olsen et. al 1954) Standard prepared from (KH_2PO_4) blank = 0.0 Colour measured at 660 m μ.

Concentration μg/ml	Reading	Concentration μg/ml	Reading
2.0	2.2	20.0	29.0
5.0	5.1	25.0	33.0
10.0	13.00	40.0	50.0
15.0	19.0	50.0	70.0

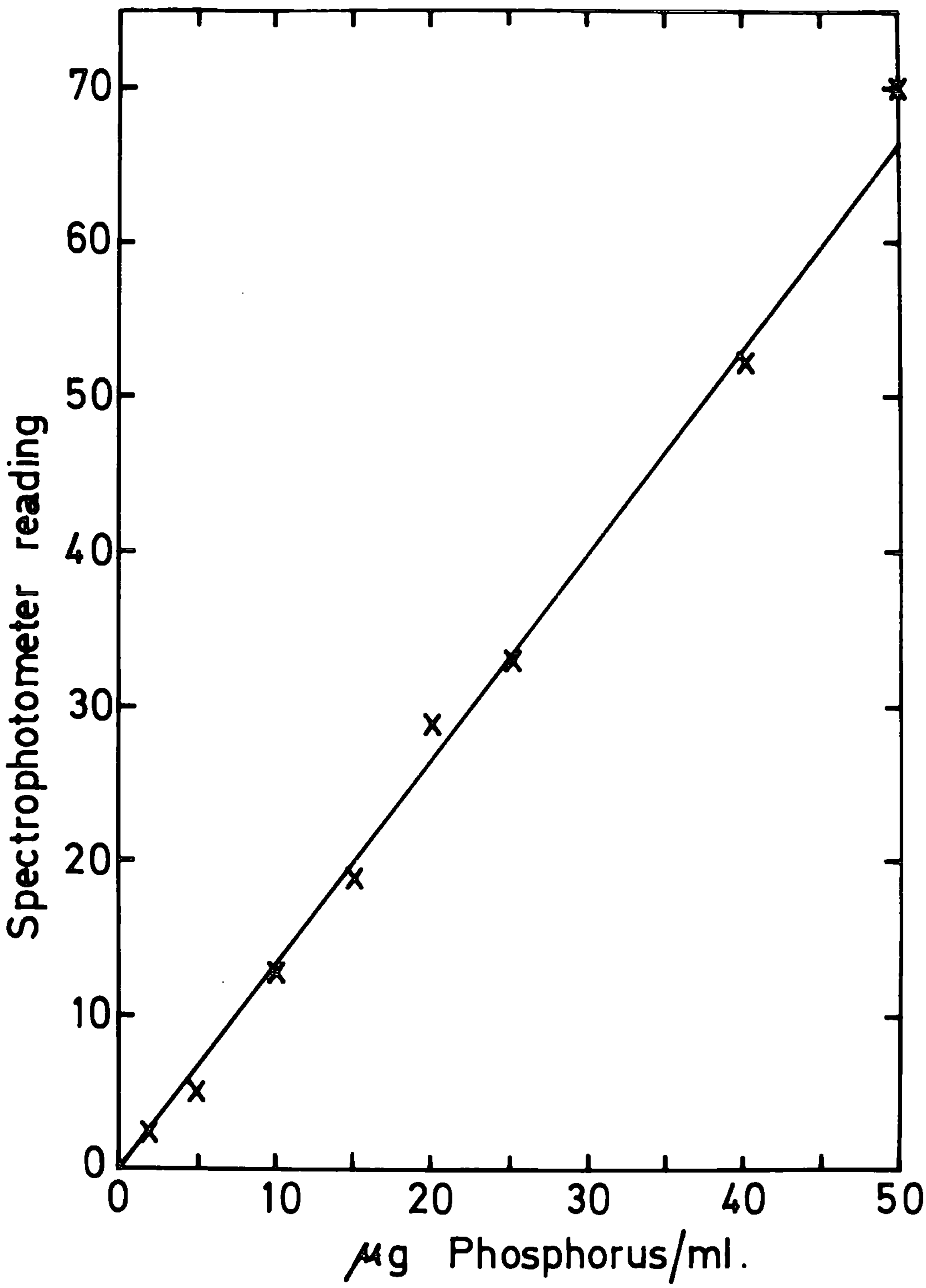


FIG. 53 Calibration Curve of phosphate.
Full details table. A 3

4. Determination of Available Nitrogen (NO_3-N; NH_3-N) in Soils

The method used in this work called Semi-micro determination method which requred micro-diffusion technique for estimating $\overset{+}{NH_3}$ described by Etherington and Morrey (1967) and modified to combine the technique with the titanous sulphate method for NO_3^- determination Black et al (1965).

Reagents

1) Titanous sulphate solution (technical grade) 5 ml of titanous sulphate in 100 ml distilled water

2) Magnesium oxide suspension. Shake 12 grams of light magnesium oxide with 100 ml of distilled water.

3) Sulphuric acid (analar) prepared at 1 normal. (36N 1.84 SP.gr)

4) Sodium chloride extraction. 2N Nacl.

Procedure

5 grams of air-dried soil was shaken with 100 ml of 2N sodium chloride solution for two hours. Allow to settle, filter through No 42 filter papers. 1 ml of filtrate taken into plastic-capped glass specimen (Johnsen and Jorgensen 3 dram vials spec. No. 3/h/3903 closure No 02/P/4006PY), followed by 2 ml of 12% light magnesium oxide (fresh prepared). This reagent should be introduced with plastic syringe. A small square disc of industrial white nylon placed in snap-on cap of the vial and held in place by the surface tension of two drops of sulphuric acid. This closure was fitted in position as soon as the magnesium oxide had been introduced.

Ammonia ($\overset{+}{NH_3}$) is displaced by magnesium oxide and absorbed by the sulphuric acid on the nylon disc. The tube then is placed horizontally on the wheel (see plate 6) and rotated for 24 hours. Remove the cap and shake disc into 10 ml of sodium nitroprusside plus 2 ml of alkaline sodium hypochlorite (must be prepared fresh) For preparation see method of nitrogen determination.

The colour is then developed in the dark. Read after one hour at least using spectro photometer at 680 micro wave and estimate the ammonia nitrogen with relation to blank with reagents without sample

To the sample solution in jj vial add 1 ml of technical grade of 5% titanous sulphate, renew the disc and cap. Rotate for 48 hours. Titanous sulphate reduces the nitrates to ammonia to be absorbed by N sulphuric acid on the nylon disc. Re-test cap using 10 ml of Sodium nitroprusside with 2 ml of alkaline sodium hypochlorite and develop the colour like above. Read at 680 micro waves and calculate the nitrate.

Standard ammonium and Nitrate Nitrogen

1) 0.9433 grams of Ammonium Sulphate (analar) $(NH_4)_2SO_4$ dissolved in 1 liter. 1 ml contains 200 μg NH_3-N.

Calibration Curves

The calibration curves of (Ammonia and Nitrate) nitrogen were prepared from different concentrations and results are tabulated in Table A4 to A5 and illustrated graphically in Figures 54 to 55.

Table A4

Calibration data for available NO_3-N

Standards prepared from KNO_3 Reduction to NH_3-N by 1 ml of $Ti_2(SO_4)_3$ Blank = 10 Colour absorption at 680 m μ

μg/ml	Reading	μg/ml	Reading
10	12	40	51.5
10	13	40	51
10	14	40	50.5
20	25.5	50	60.5
20	25	50	60
20	24.5	50	61.5

Table A5

Calibration data for available NH_3-N

Standards prepared from $(NH_4)_2SO_4$ Reduction by 2 ml of Magnesium Oxide (MgO), Blank = 5 Colour absorption at 680 m u

μg/ml	Reading	μg/ml	Reading	μg/ml	Reading
0.5	4	2	14	4	32.2
0.5	4.5	2	14	4	32.1
0.5	3.5	2	14	4	32.4
1.0	8.9	3	21		
1.0	8	3	23		
1.0	7.9	3	25		

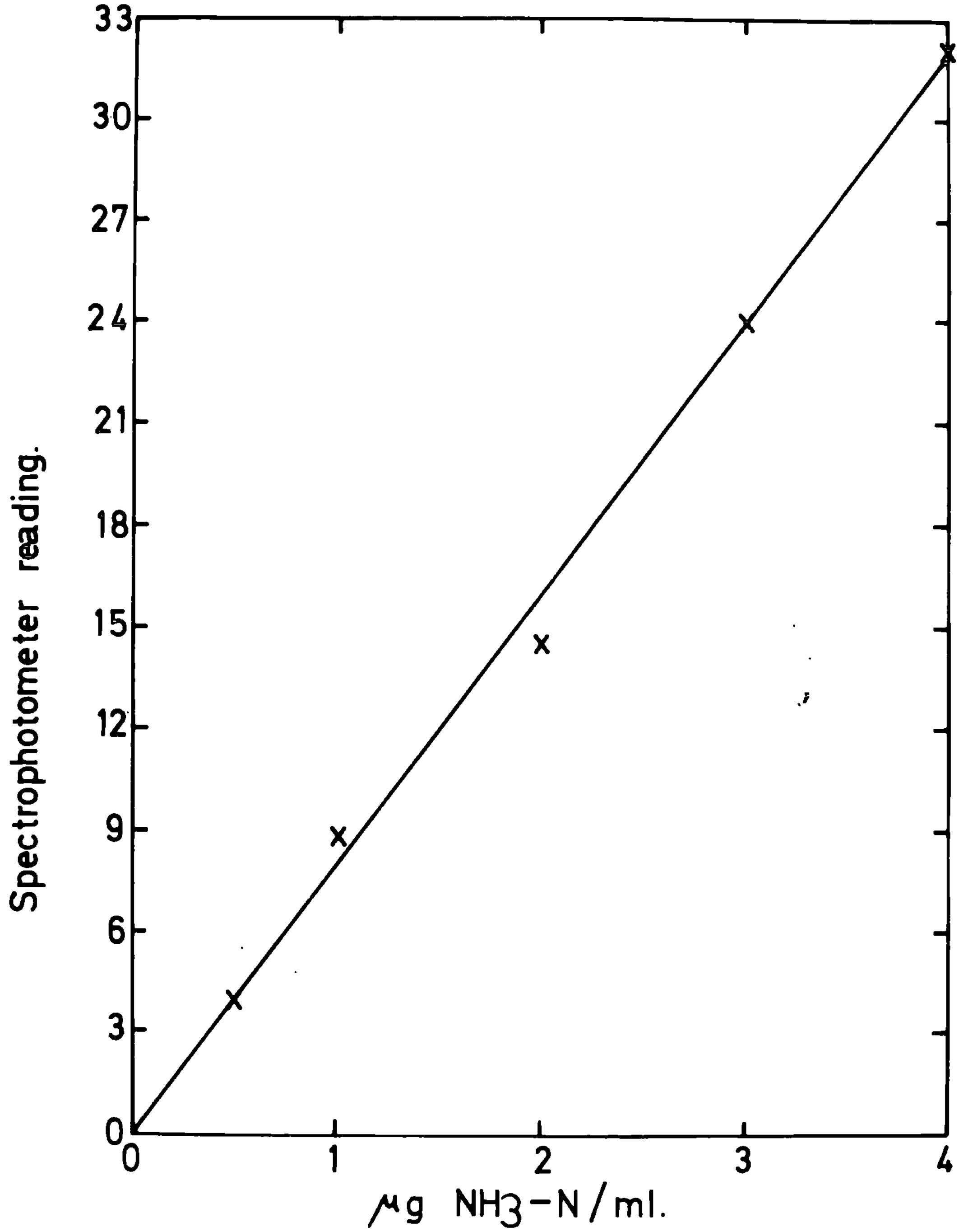


FIG.54 Calibration Curve of Available Ammonia-Nitrogen. Each point mean of three; Full details table.A4

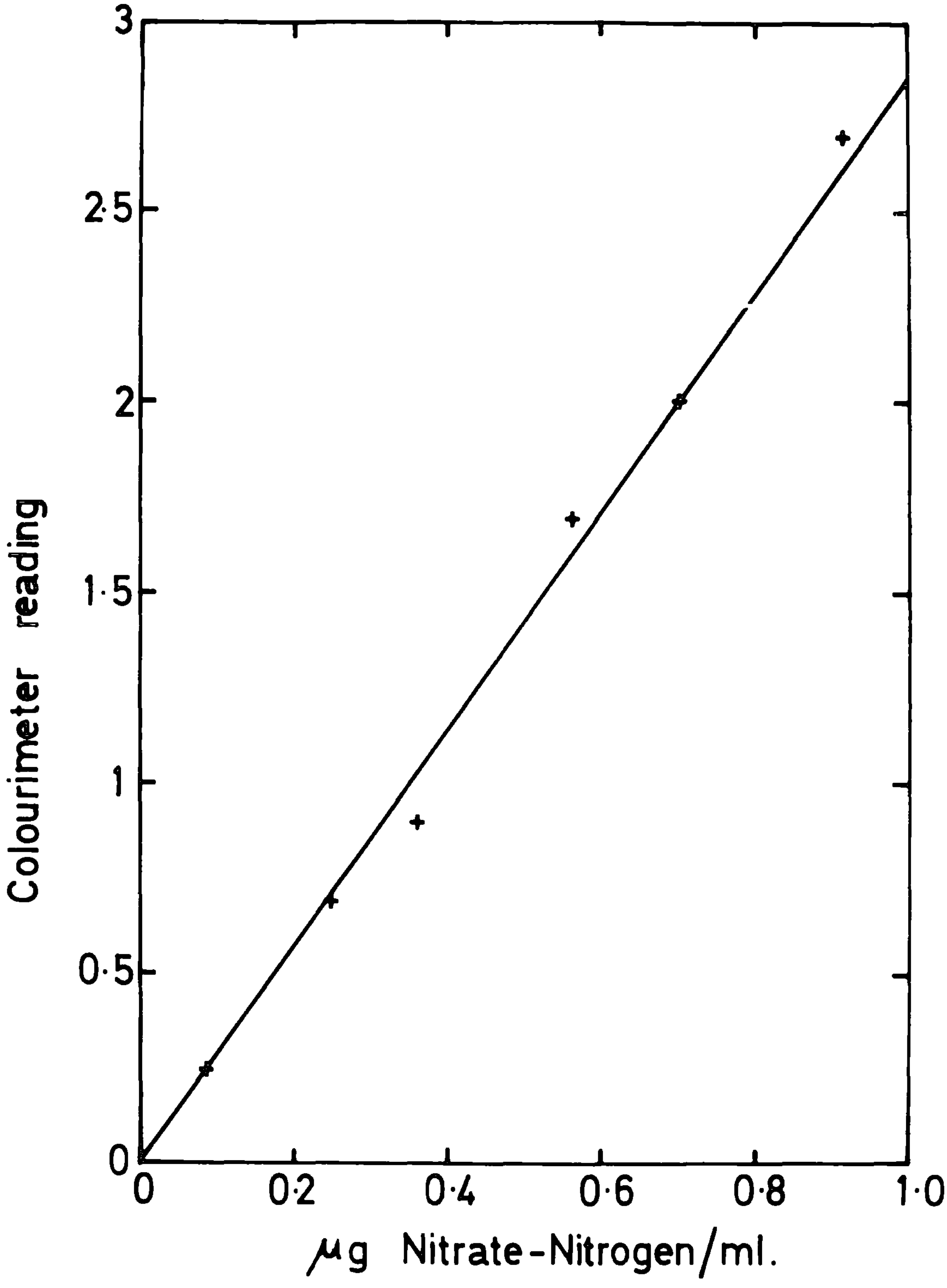


FIG. 55 Calibration Curve of Nitrate-Nitrogen. Each point mean of three; Full details table. A 5

5. Determination of Available Potassium in Soil

Flame photometer procedure described by Black (1965)

Reagents

1) Ammonium acetate (NH_4OAC). 1 N. adjusted to PH 7.0. Add 58 ml of glacial acetic acid (analar) to about 600 ml of distilled water. And then add 70 ml of concentrated NH_4OH (Analar), Sp.gr. 0.90. Cool, and adjust the PH to 7.0 using acetic acid or ammonium hydroxide. Dilute the solution to 1 liter. Store in a pyrex bottle.

2) Standard potassium solution. 0.9533 grams dissolved in NH_4OAC (Potassium chloride dried at 105^{o}C for one hour). Then make up the solution to 500 ml with Ammonium acetate. This solution contains 1000 P.P.M.

Procedure

5 - 10 grams air-dried soil (depends on the concentration of potassium), in a 50 ml centrifuge tube. Add 25 ml ammonium acetate, shake for 10 minutes, centrifuge the tube. Decant the supernatant into 100 ml volumetric flask. Make three additional extractions in the same way. Make the combined extracts to 100 ml with ammonium acetate. Mix gently, estimate potassium on flame photometer.

Calibration Curve

Prepare different dilutions 0-60 P.P.M plot the flame photometer reading against concentrations. Blank prepared in the same way without addition of soil sample. Results of standard curve/Fig.56. are shown in Table A6 on the following page.

Table A6

Calibration data for available potassium using flame photometer. Standard prepared from potassium chloride dried at 105°C. Blank = 0.0

Concentration P.P.M	Readings
5.0	5.0
10.0	11.0
20.0	24.0
40.0	46.0
60.0	66.0

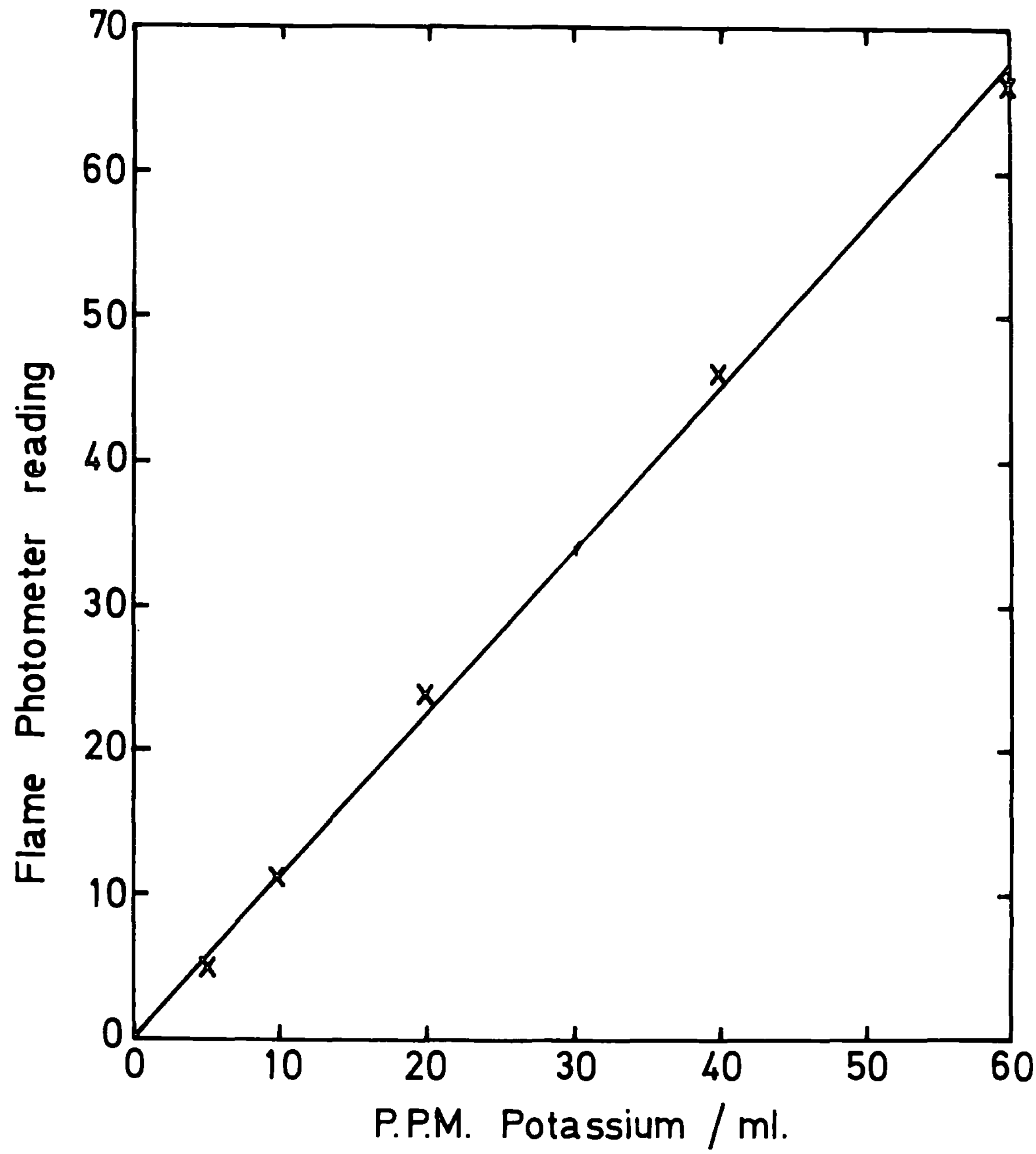


FIG. 56 Calibration Curve of Potassium.
Full details table. A 6

6. Determination of Nitrite-Nitrogen in Soil

It was found convenient to determine Nitrite-Nitrogen in the soil collected, on the same extract as was used for determination of Nitrate and ammonia Nitrogen by cooled distillation on the wheel.

Thus the extractant 2N NaCl was not acidified as this would not prevent No_2 being determined. Black (1965)

Reagents

1) 0.5 grams Sulphonilamide disaolved in 100 ml of 2.4 M HCl. (2.4 M HCl = 20.5 ml of 11.7 N HCl in 100 ml water)

2) 0.3 grams N-(1-naphthyl) ethylendiaminehydrochloride in 100 ml of 0.1 M HCl (0.1 M HCl = 0.855 ml of 11.7 NHCl in 100 ml water)

Standard. Na - Nitrite.

3) 49.2 milligrams sodium nitrite in 100 ml distilled water

* 100 ml μg N/ml (133 mg/L = 25 p.p.m)

= 27.8 μg N/ml

Procedure

5 grams air-dried soil in 100 ml 2N NaCl, shake for 2 hours. Filter using No 42 paper. Aliquot (depends upon the concentration of NO2) Make up to 40 ml with 2N Sodium chloride. Add 1 ml of reagent (1). Wait for 5 minutes, add 1 ml of reagent (2). Stand for 20 minutes, dilute to 50 ml with distilled water. Measure colour at 520 micro waves using specrophotometer.

Calibration Curve

Was prepared by using different dilutions of the standard and follow the procedure above. Blank was prepared in the same way without sample. Data are shown in Table A7 and in figure 57.

Table A7

Calibration data for Nitrite Nitrogen Standard prepared from Sodium Nitrite. Blank = 0.6 Colour was measured at 520 m u.

Concentration µg/ml in 50 ml	Reading
1.11	7.1
5.56	27.5
11.10	56.0
22.2	100.0

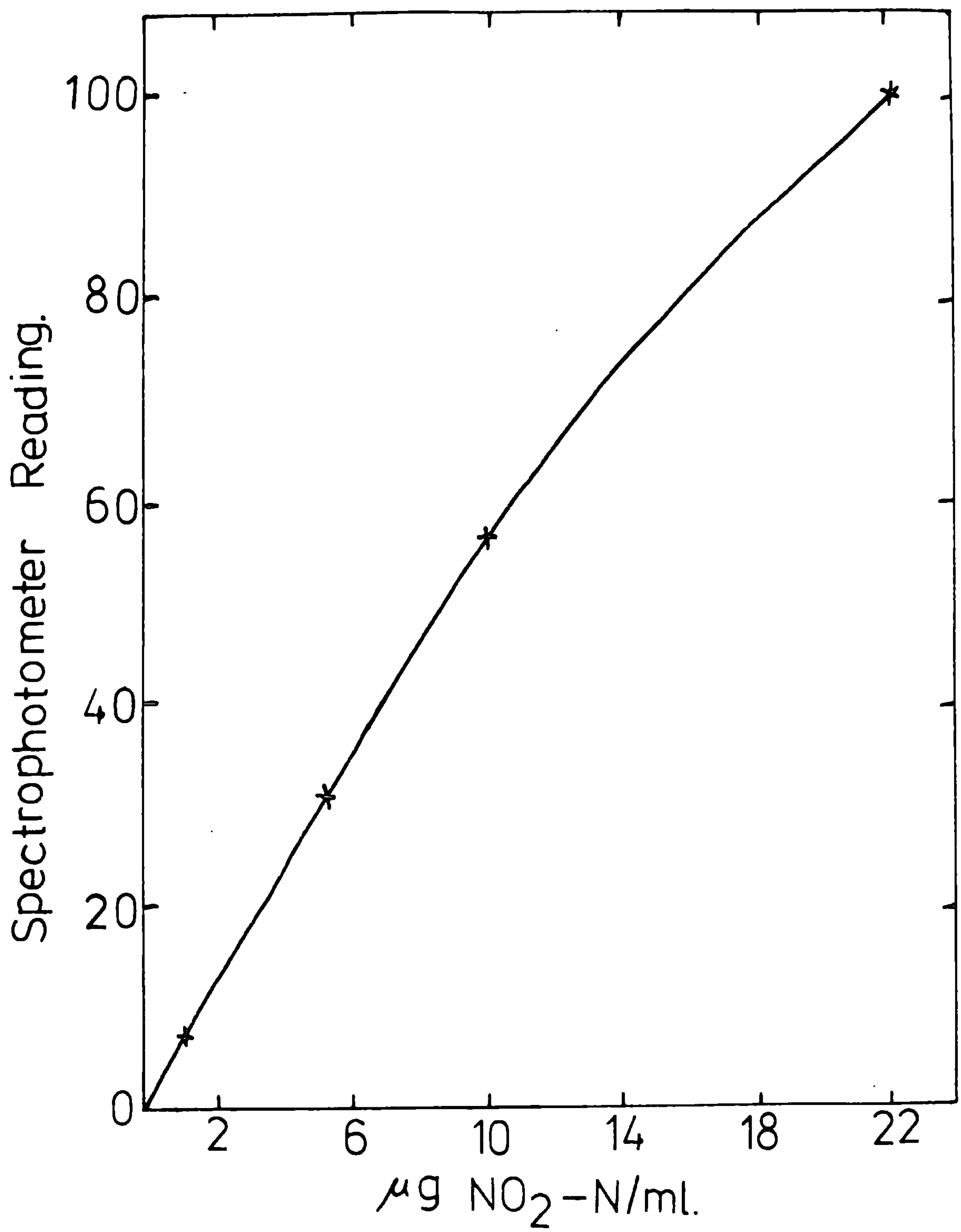


FIG. 57 Calibration Curve of NO_2-N.
Full details table. A7

7. Loss on Ignition and Moisture Determinations in Soil

Organic content of the soil was estimated by finding the loss of weight on ignition rather than by the more accurate wet or dry combustion methods as the accuracy required did not justify the time-consuming techniques.

Method

The soil samples collected have been air-dried, crushed gently and passed through a 2 mm mesh sieve. The material that passes through is known as fine earth samples.

1) 10 grams of this sample is taken into a weighed crucible.

2) place in an oven at 105°C for at least 4 hours

3) remove from oven and reweigh.

The percentage moisture in the soil calculated as a percentage of air dry soil.

Let weight of crucible + air-dry soil = A g

" " " " + oven-dry soil = B g

" " " " + moisture = $\frac{A - B}{10} \times 100$

4) The oven dry soil is placed in muffle furnace at 800°C for 2 hours.

5) Remove from furnace, cool and then reweigh.

The percentage loss on ignition calculated as a percentage of the oven dry soil.

Let weight of crucible + ignited soil = C g

$$\% \text{ loss on Ignition} = \frac{B - C \times 100}{10 - (A-B)}$$

8. Soil Nitrogen Fixation Method

(Acetylene Reduction Assay)

The method described by Stewart *et al* (1967) and has been modified by Waughman (1971).

Procedure

The experiments were carried out in 100 ml. capacity glass (conical flasks). The main requirement to have enough space for the acetylene to react with gases.

30 grams fresh soil from each field from 0 - 6 in. depth were taken around barley roots, into the conical flask (incubating chamber), then sealed by No. 30 Suba seal stopper. 20% by volume acetylene (that is 22% of incubating chamber volume $\frac{22}{110}$ X 100 = 24.2c.c) was injected through the suba seal stopper using a hypodermic syringe. Blanks were carried out minus the sample (4 replicates were done).

All the gases in the incubation chambers were equilibriated using a hypodermic needle. 2.5 ml. of 5% glucose were added.

Incubation has been carried out at average of 12^{o}C.

Analysis

The gas samples were analysed using a varian 1200 gas chromatograph fitted with a 12 ft. X $\frac{1}{8}$ in. column filled with propak R. Nitrogen was used as a carrier gas and detection was made with hydrogen flame detector. Running the column at 25^{o}C allowed good flame separation of the C_2H_2 and 45 seconds for C_2H_4.

1 ml. of the gas samples was injected into the column of the chromatograph using 1 ml. plastic syringe, the highest peaks of C_2H_2 and C_2H_4 were recorded.

μMoles of C_2H_4/g/hour was calculated and the rate of C_2H_4 produced /g/hour, was also calculated. For details see Figs 12 to 19.

The amount of N_2 fixed/g/hour was calculated and is shown in Table 35.

The factor applied to calculate the nitrogen fixed from the ethylene produced was 3:1. Stewart (1967), Hardy (1968) and Rice (1971).

1 Mole N fixed for 3 Moles ethylene produced.

Calculation

T = time from start of incubation with acetylene.

R.A.P. = Range X Attenuation reading X peak height on gas chrom.

Ethylene R.A.P. 1 gram = R.A.P. corrected to value /gram.

Total C_2H_4 produced in non Moles

$$= \frac{\text{R.A.P. X Volume of incubation flasks}}{\text{Volume of soil X Machine factor (28)}}$$

$$= \frac{\text{R.A.P. X 110}}{\text{1 X 28}}$$

Mean Rate of C_2H_4 produced in non Mole /g/hr

$$= \frac{\text{Total } C_2H_4 \text{ produced}}{\text{Time (hr)}}$$

= actual rate of Ethylene at different values at T

1 Mole N_2 fixed for 3 Moles C_2H_2 reduced — Stewart *et al* (1967), Hardy *et al* (1968), Rice W.A. (1971)

$$\frac{\text{Rate of } C_2H_4 \text{ produced}}{3} = N_2\text{Fixed /g/hr}$$

μM/g/season

i.e. 10.87 μM/g/season

= 2.7175 μMN/g/hr

= 65.22 μMN/g/day

= 0.00183 g N/g/day

$$\frac{0.00183 \times 2.205}{1000} = \text{lb/g/day}$$

= 0.000004 lb Nitrogen fixed / day

2227500 lb/acre/year dry wt. at depth 17 Cn^2 Knowles (1965)

∴ 2227500 X 0.000004 = 8.91 lb Nitrogen Fixed/acre/season

X4 = 35.6 N fixed is lb/acre/season

9) Tissues, Soils and Water Analysis

Acid Digestion

This method is based on the oxidation process, using a very strong mixture of concentrated nitric and perchloric acids. (Nitric acid is the most effective oxiding agent). The method has been modified from the technique described by Piper (1950), Jefferies et al. (1964) and used by Rieley (1967).

Reagents

1) Concentrated nitric acid (Analar)

2) 60% W/v concentrated pechloric acid (Analar)

Procedure

A) Tissue Analysis

Plant materials washed in tap and then distilled water to get rid of soil particles, then were dried in oven at 80^{o}C for 24 hours. Plant samples were ground using electric coffee grinder to allow more effective digestion. 0.5 - 1.0 gram samples were transferred into 250 ml. conical flask, 20 ml conc. nitric acid added in fume cupboard. Heated on a sand bath.

5 ml. conc. perchloric acid were added. Great care was taken at the beginning of the digestion to minimize fuming which could have resulted in loss of part of the samples. With increased heat digestion was continued until a small volume of the solution remains in the flask.

Small quantities of distilled water were then added. Heating continued (water helps decreasing the acidity) until the solution becomes clear (this process required 4 hours). Flasks were then taken out of the fume-cupboard and allowed to cool down, then the solution was diluted with about 100 ml. of distilled water and filtered at the pump. The filtrate was then made up to 250 ml. in volumetric flasks. Blanks, minus the plant material, were prepared in the same way.

B) Soil Analysis

Soil samples dried at 105°C for 48 hours were passed through a 2mm sieve after grinding. 2 grams samples were transferred into 250 ml. conical beaker, and 20 ml of conc. nitric acid added. Samples then were placed on sand bath in fume-cupboard where they were heated gently over night. 5 ml. conc. perchloric acid were then added. Digestion was begun over low heat to minimize fuming which could have resulted in loss of material, and continued at a higher temperature until only small volume remaind (solution becomes white). This process required about 4 hours.

The beakers were then removed from sand bath, cooled and 150 ml distilled water added after filtration through No. 42 paper at the pump.

The solution was made up to 250 ml. with distilled water. Blanks were prepared in the same way without soil samples.

C) Water Analysis

3 X 100 ml. samples evaporated to 2 ml. and then made up to 25 ml. with distilled water and used for NO_3-N and total nitrogen. For totals 2 X 100 mls samples taken with 5 ml. conc. perchloric acid and heated on sand bath to small quantities (about 5 ml) then made up to 25 ml with distilled water. Blanks were prepared in the same way using distilled water.

10) Dentrification

Owing to the unavailability of the more accurate method using labelled ^{15}N, the following method was used.

Experimental procedure

The method as used described by Bremner and Show (1958).

Sampling Procedure

Soil samples were collected from Haughley farm from 0 - 6 in. in depth and 6 - 20 in. Sub samples were mixed thoroughly and air-dried for 10 days.

5 grams of mixed soil were transferred into a 30 ml. serum bottle. 2 ml. of distilled water containing 4000 p.p.m. Nitrate-Nitrogen (as A.R. KNO_3) were added. Samples were incubated at 25°C in the oven for 30 days. Changes in nitrate-nitrogen (as losses) on an incubation were determined by shaking the contents of one set of the bottles (3 replication were used every time) before and after incubation and at intervals between.

11. Determination of Total Organic Nitrogen in Plants, Soils and Water Samples

The method was employed for determination of nitrogen in plants, soil and water samples. This method was described by Allen and Whitfield (1965) and has been modified for this purpose (Kjeldahl Method).

Reagents

1) Standard. 2.357 grams of ammonium sulphate dissolved in 1 liter distilled water.

2) Phenol-Sodium nitroprusside. 12.0 grams of phenol (Analar) dissolved in 1 liter distilled water. 200 ml. of sodium hydroxide (sodium hydroxide prepared by taking 1.7 grams NaOH in 100 ml. distilled water) added, followed by sodium nitroprusside (0.06 gram of nitro-prusside dissolved in a small quantity of distilled water). The whole was made up to 2 liters and stored in a dark bottle.

3) 30% Hydrogen peroxide (Analar)

4) Alkaline sodium hypochlorite solution. 10 ml. of sodium hypochlorite (10% available chloride) added to 250 ml. of 1.7% NaOH. Mix well.

5) Selenium with Sulphuric acid. Dissolve 0.1 gram Selenium powder in 100 ml. sulphuric acid (Analar). Heat gentle to dissolve the Selenium.

Procedure

Digestion A. 100 milligrams plant materials (dried) or
B. 0.5 grams of dried soil samples, or
C. 4 ml. of water samples into Kjeldahl flasks.

Then carefully add 2 ml. of selenium in sulphuric acid, followed by 1 ml of 30% hydrogen peroxide to destroy the organic matter.

Once the fuming had ceased, the solution was heated for 1½ hours either on the electric Kjeldahl block, or the digestion block.

The tubes are calibrated at 20 ml. (The digestion block consists of a piece of mild steel 6 in X 8½ in. X 1½ in deep in which 30 holes ⅞ in. in diameter, 1 in. between centers are drilled to a depth of 1 in. The block is heated by four 375 watt wash-boiler elements clamped to its base and the heating is controlled by a simmerstat. The sides of the block and heaters are screened by asbestos side-pieces 7 in.deep and the digestion tubes are held upright by means of a strong 1 in. square wire mesh which rests on the top of the sides). Until the colour of the digestion becomes clear (colourless).

Blanks were prepared in the usual way.

Dilutions After the digestion terminated, the solution was transferred into a volumetric flask and made up to 20 ml. of distilled water. 2.5 ml. of the solution was taken and diluted to 100 ml. with distilled water. 1 ml. of this contains 0.025 ml. of the original digest.

Colour Development Aliquots of 0.025 ml. (1 ml) of the digest are transferred into 3 in. X ½ in. specimen tubes followed by 5 ml. of phenol-sodium nitroprusside solution and then 1 ml. of (immediately) alkaline sodium hypochlorite. The colour was allowed to develop for more than 45 minutes in a dark place, when intensity was measured using spectrophotometer at 680 m u.

Standard solutions. Aliquots of 1,2,3,4,5,6,7,8,9,10 and 20 ml. of the standard containing 0.500 mgm nitrogen added to the blank digest and diluted to 20 ml. with water. Follow the same procedure for colour development.

All reagents were kept at the same temperature. Calibration curve is shown in Figure 58 and Table A8 for colourimeter, and Figure 59 and Table A9 for spectrophotometer.

Table A8

(Colourimeter)

Calibration data for total organic Nitrogen (Micro-Kjeldahl). Standards prepared from $(NH_4)_2\ SO_4$

Blank = 0.001 using blue filter

Concentration µg/ml	Readings	Concentration µg/ml.	Readings
0.0005	0.6	0.0025	2.5
0.0010	1.3	0.003	3.1
0.0018	1.9	0.004	3.8

Table A9

(Spectrophotometer)

Blank = 10

Concentration µg/ml.	Readings	Concentration µg/ml.	Readings
0.5	6.0	2.5	25
1.5	12.0	3.0	31.0
2.0	18.0	4.0	37.5

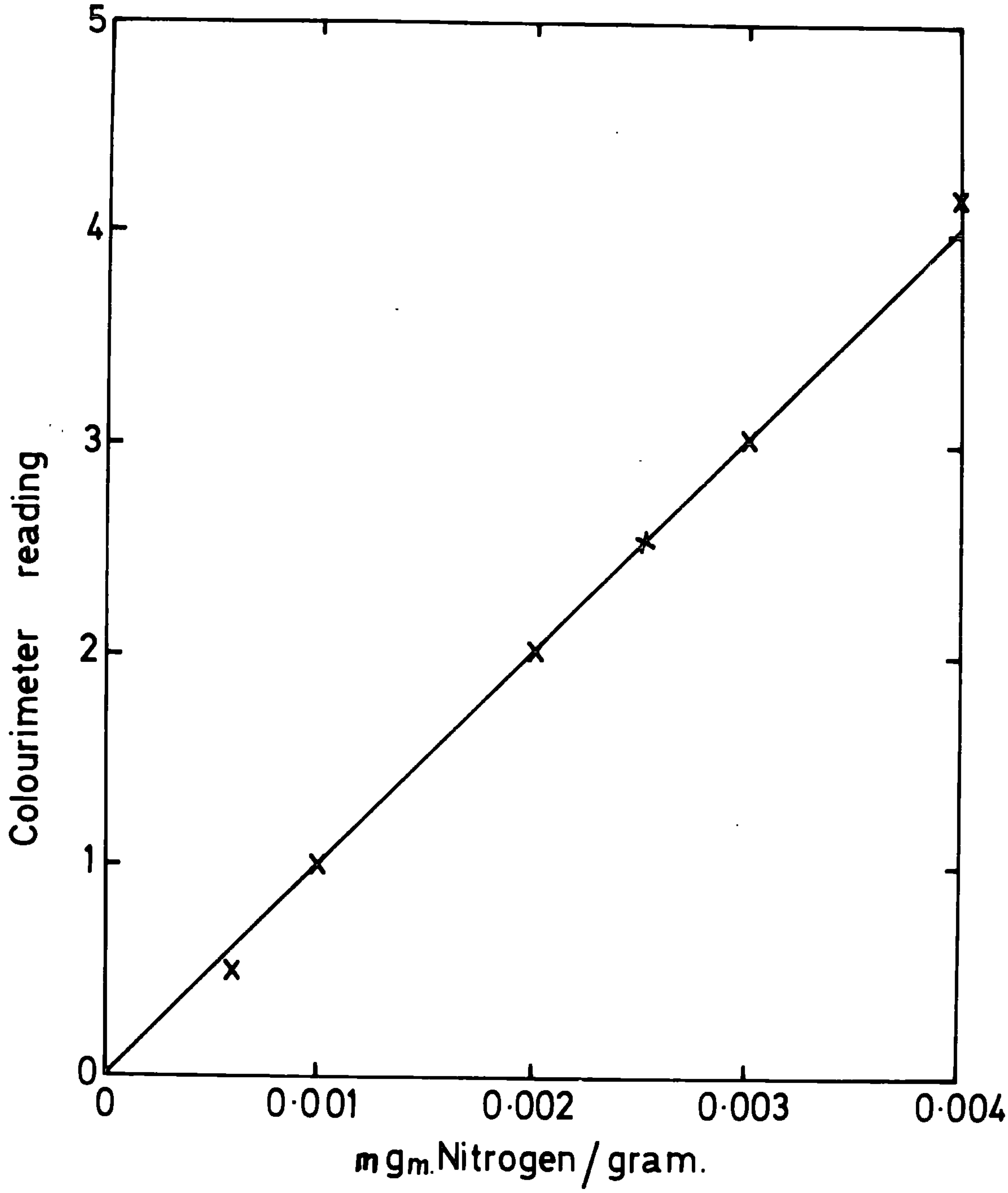


FIG. 58 Calibration Curve of Nitrogen.
Full details table. A 8

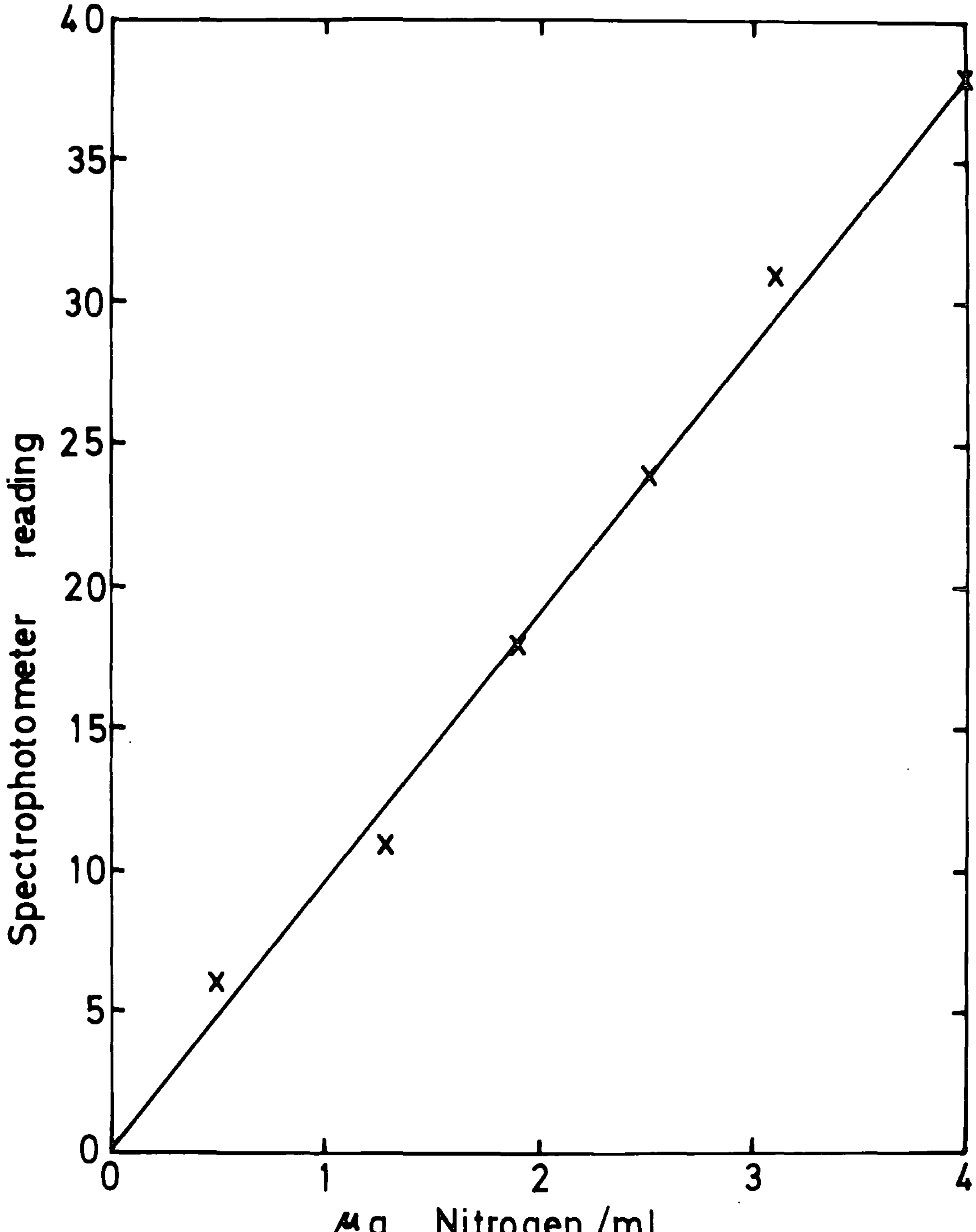


FIG. 50 Calibration Curve of Total Organic Nitrogen. Each point mean of three; Full detils table. A 9

12. Determination of Phosphorus (in plant materials, soil and water samples

The method used in this work was discribed by Deniges (1920) and modified by Fogg and Wilkinson (1958) and is based on replacement of stannous chloride by ascorbic acid.

Reagents

1) Ammonium molybdate - Sulphuric acid solution. 10.0 grams of ammonium molybdate (Analar) dissolved in 70 ml. of distilled water, and made up to 100 ml. Carefully add 150 ml. Sulphuric acid (Analar) to the same volume (150 ml.) distilled water. The acid used is Sp. gr. 1.84. Mix the solution at the addition. Allow to cool, and add to ammonium molybdate.

2) Ascorbic Acid

3) Sodium hydroxide (Analar)

4) Standard phosphate. 0.7669 grams of the analar potassium dihydrogen orthophosphate dissolved in distilled water and diluted to 1 liter. For use dilute 25 ml. of this solution to 1 liter.

1 ml. = 10 ug of P_2O_5.

Procedure

(Solutions prepared from acid digestion was used)

Aliquot of sample (depends upon the concentration of phosphate in the sample), transfer to a beaker of 100 ml. volume. The samples were neutralized with sodium hydroxide, and then made up to 40 ml. with distilled water.

4 ml. of Ammonium molybdate were then added with mixing gently, followed by 0.1 gram ascorbic acid and then boiled for 1 minute. Blanks were prepared by the same procedure. Measure the optical density of blank and samples (after diluting

the sample into 50 ml. with distilled water) were in the spectrophotometer using 660 m u.

Calibration Curve

Standard solution of ranges from 0 - 50 ug phosphates per mo. and to 130 ug phosphate per mo. were prepared as below:

0, 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 7.0, 10.0, 13.0 ml. portions. The volume was then diluted to 40 ml. with distilled water, then follow the procedure above.

The data are tabulated in Table A10 and shown graphically in Figure 60.

Table A10

Calibration data for phosphorus. Standard prepared from potassium dihydrogen orthophosphate. Blank = 0.5 using 660 microwaves length.

Concentration µg/ml.	Reading	Concentration µg/ml.	Reading
0.0	0.0	40.0	8.0
15.0	1.0	50.0	10.2
10.0	2.1	70.0	16.6
20.0	4.0	100.0	22.7
30.0	6.2	130.0	30.0

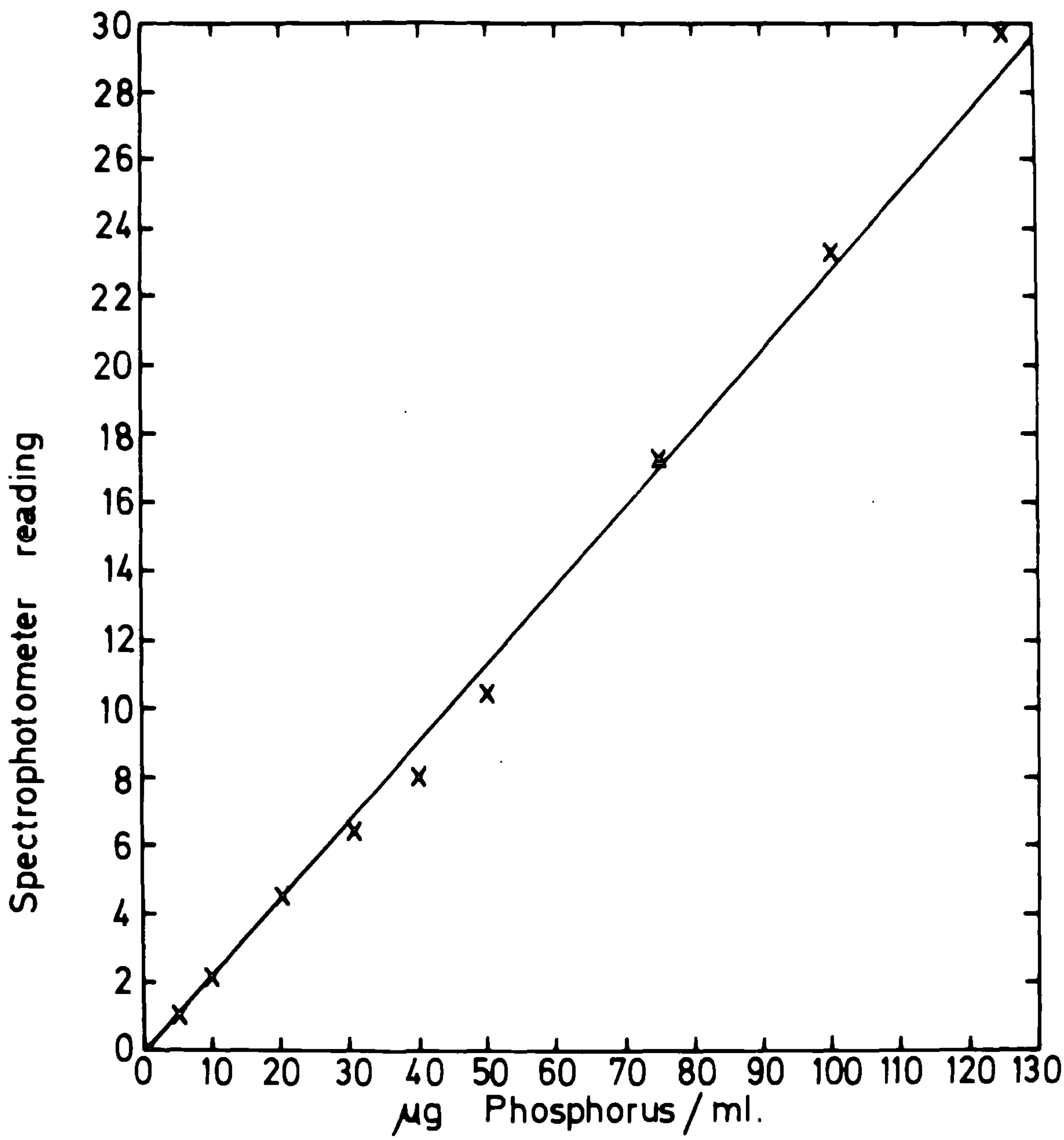


Fig. 60 Calibration Curve of Phosphate. Full details table. A 10

13. Determination of Sodium and Potassium (in plant materials, Soils, and Water)

The method was described by Dean (1960). Eel Flamephotometer was used. The standard solutions were prepared. Calibration curves also were illustrated in graphs. See Figs 61 to 62 and in Tables A11 and A12.

Standard Solutions

1) Sodium. 2.542 grams of sodium chloride (dried at 110^{o}C) dissolved in water and then make it up to 1 liter with distilled water. This solution contains 1000 p.p.m. Na.

2) Potassium. 0.9533 grams of potassium chloride (dried) dissolved in 500 ml. distilled water. Mix gently. This solution contains 1000 p.p.m.K.

Solution prepared from acid digestion method were used in this determination

Table A11

Calibration data for sodium. Standard prepared from Sodium Chloride. Blank = 0. Readings were measured by flame photometer

Concentration ppm	Reading
10	9
20	20
30	33
40	41
60	59
80	81
100	100

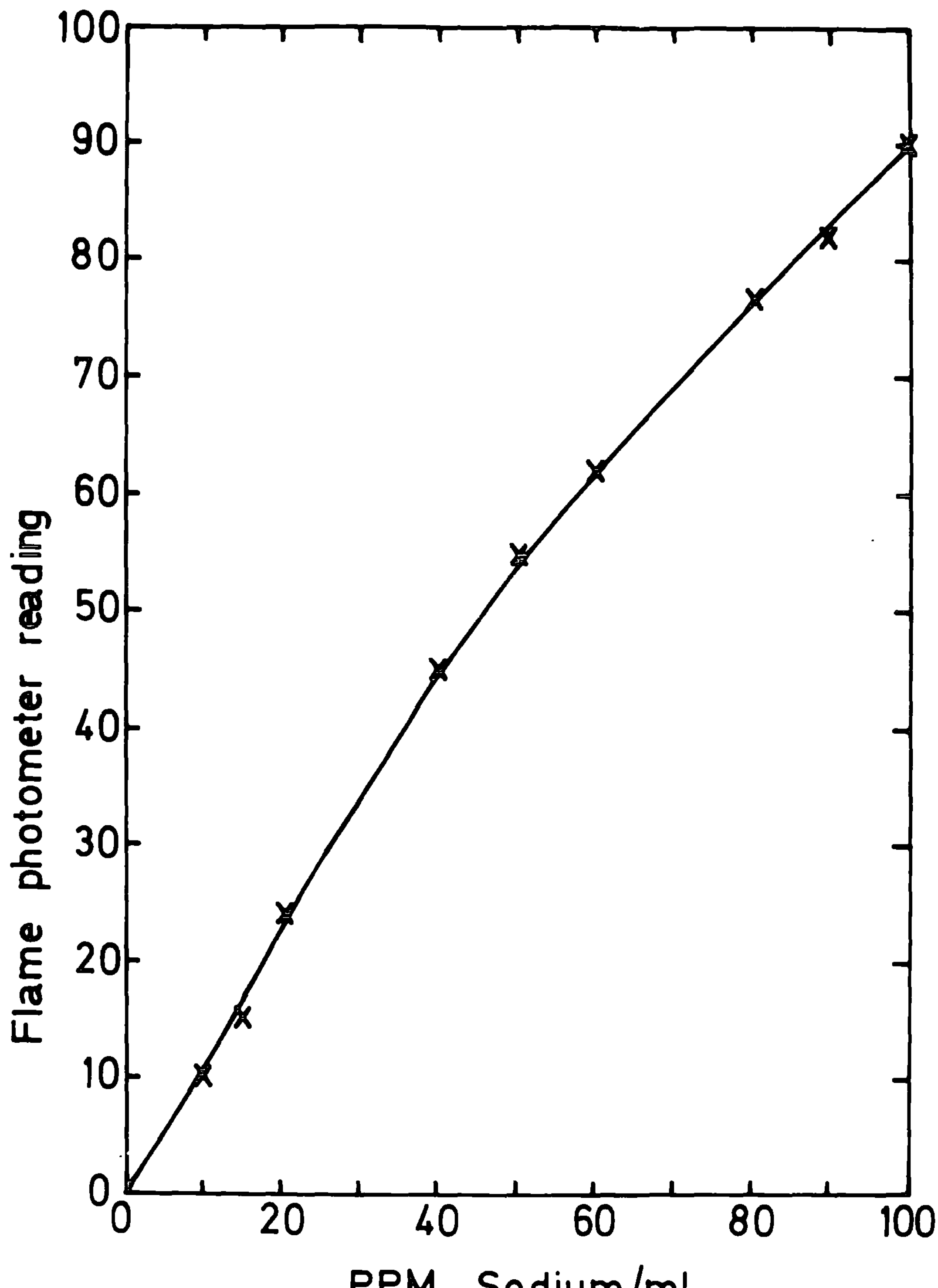


FIG.61 Calibration Curve of Sodium. Full details table. A11

Table A12

Calibration data for potassium. Standard prepared from potassium chloride. Blank = 0 Readings were measured by flame photometer

Concentration ppm	Readings
10	10
15	14.5
20	24
40	45
50	55
60	62
80	78
90	82
100	90

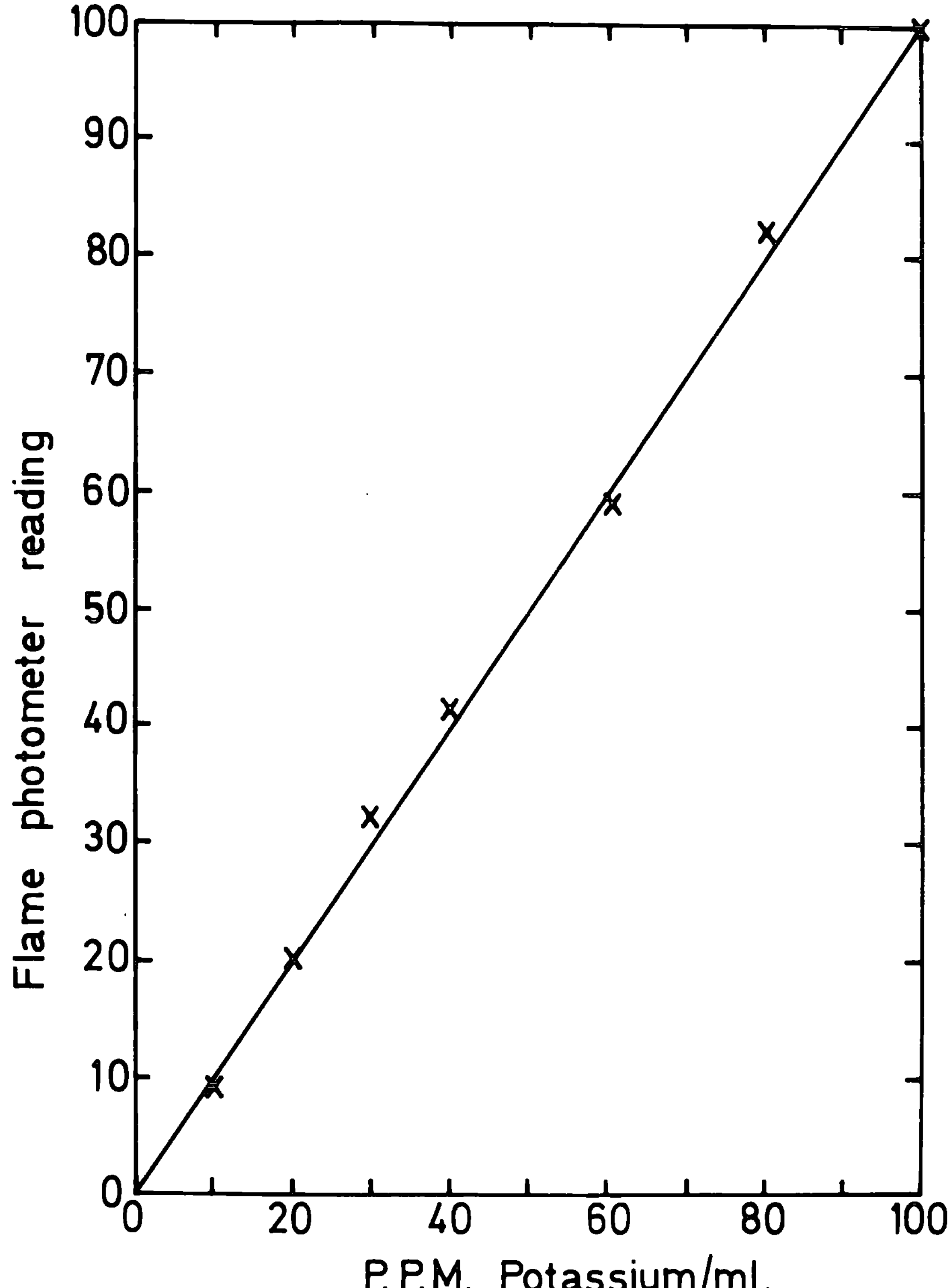


FIG. 61 Calibration Curve of Potassium.
Full details table. A 12

14. <u>Determination of Calcium in plant materials, soils and water</u>

This method has been described by David (1960), Williams (1960) and discussed in detail with special reference to interferances by Rieley (1967).

<u>Reagents</u>

Standard solution. 6.24 grams of calcium carbonate (Analar) dissolved in 25 ml of 6N hydrochloric acid. Then make up to 500 ml with distilled water. 5 ml. of this solution taken and diluted to 500 ml with distilled water. 1 ml. contains 50 ppm Ca.

<u>Calibration Curve</u>

Different dilutions prepared from the standard and read using the EEL Atomic Apsorption Spectrophotometer. Blank should be prepared.

<u>Solution prepared from acid digestion method was used in this determination</u>

EE1 Atomic Apsorption Spetrophotometer used at 423 m u 0.04 mm Slit. N.B. Calcium found to be effected by phosphate and the presence of which can seriously reduce absorption. So lanthanum was added to overcome these interferences (87 grams lanthanum chloride added to 100 ml. of N HNO_3, Cool and make up to 500 ml. with distilled water). Data for standard curve are shown in Table A13 and illustrated in Figure 63.

Table A 13

Calibration data for calcium. Standard prepared from $CaCO_3$. Blank = 0 Readings were measured using EE1 Atomic Absorption spectrophotometer at 423 m μ and 0.04 mm slit

Concentration ppm	Reading	Concentration ppm	Reading
0.0	0.0	50.0	3.8
10.0	0.7	80.0	5.7
25.0	1.9	100.0	7.0

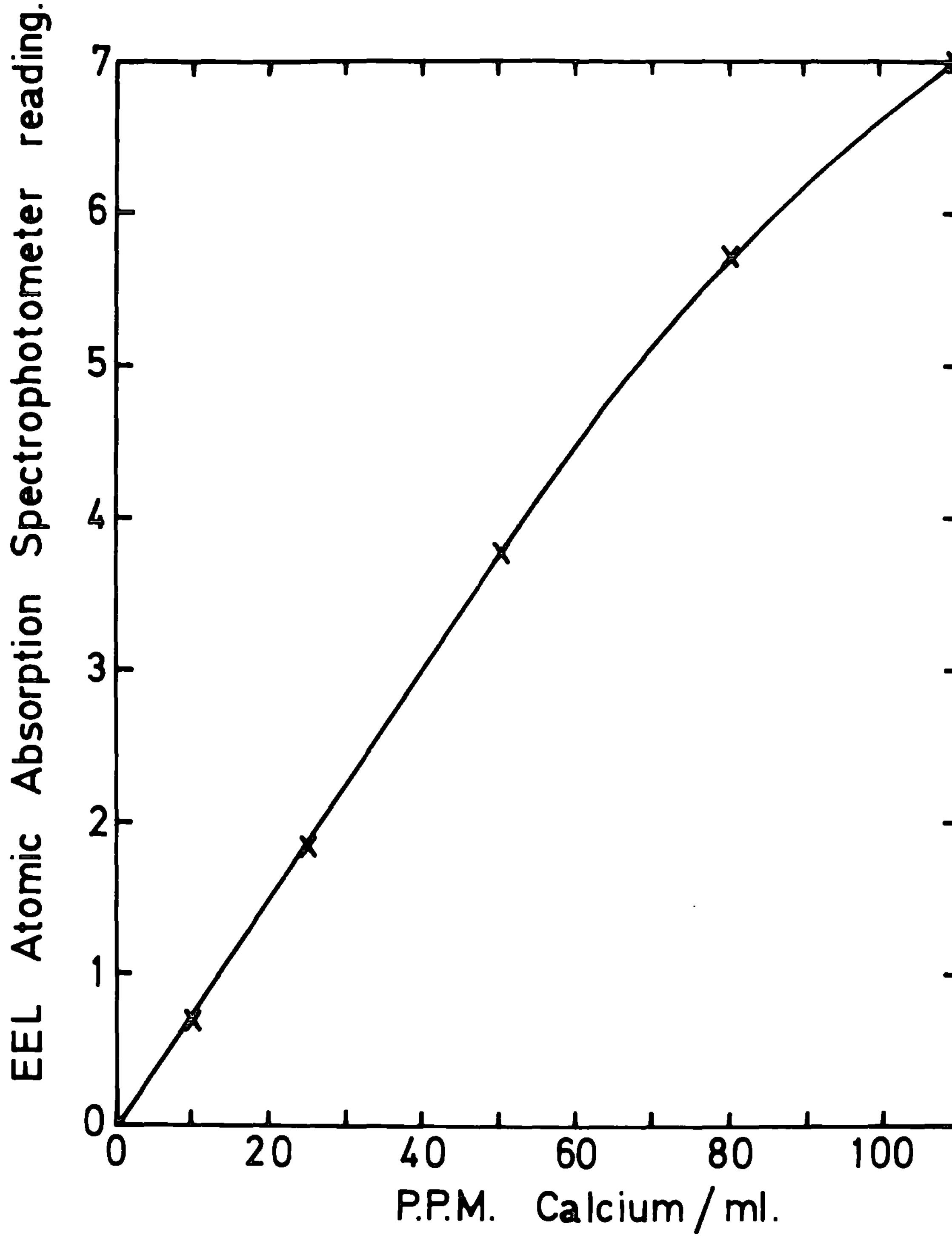


FIG. 63 Calibration Curve of Calcium.
Full details table. A 13

15. Determination of Magnesium in plant materials, soils and water

The method used was described by David (1960) and Allan (1958)

Standard Solution

0.829 grams of powdered anhydrous magnesium oxide (MgO) dissolved in 41.5 ml of N concentrated acid. Make up the solution to 500 ml. with distilled water.

2.5 ml. of this solution contains 5 p.p.m. Mg.

Calibration Curve

A range of differing dilutions were prepared and read off against a blank using the EEL Atomic Absorption Specto-photometer.

Solution prepared from acid digestion method to be used in this Determination

EEL Atomic Absorption Spectrophotometer used at 285 m y and 0.04 mm slit. The data for calibration curve are tabulated in Table A 14 and shown in graph. See Figure 64.

Table A 14

Calibration data for magnesium. Standard prepared from MgO. Blank = 0.0 Readings were measured by EEL Atomic Absorption Spectrophotometer at 285 m μ and 0.04 mm. Slit.

Concentration ppm	Reading	Concentration ppm	Reading
0	0.0	20	8.0
1	0.9	50	9.0
2	2.5	75	9.4
10	6.5	100	10.0

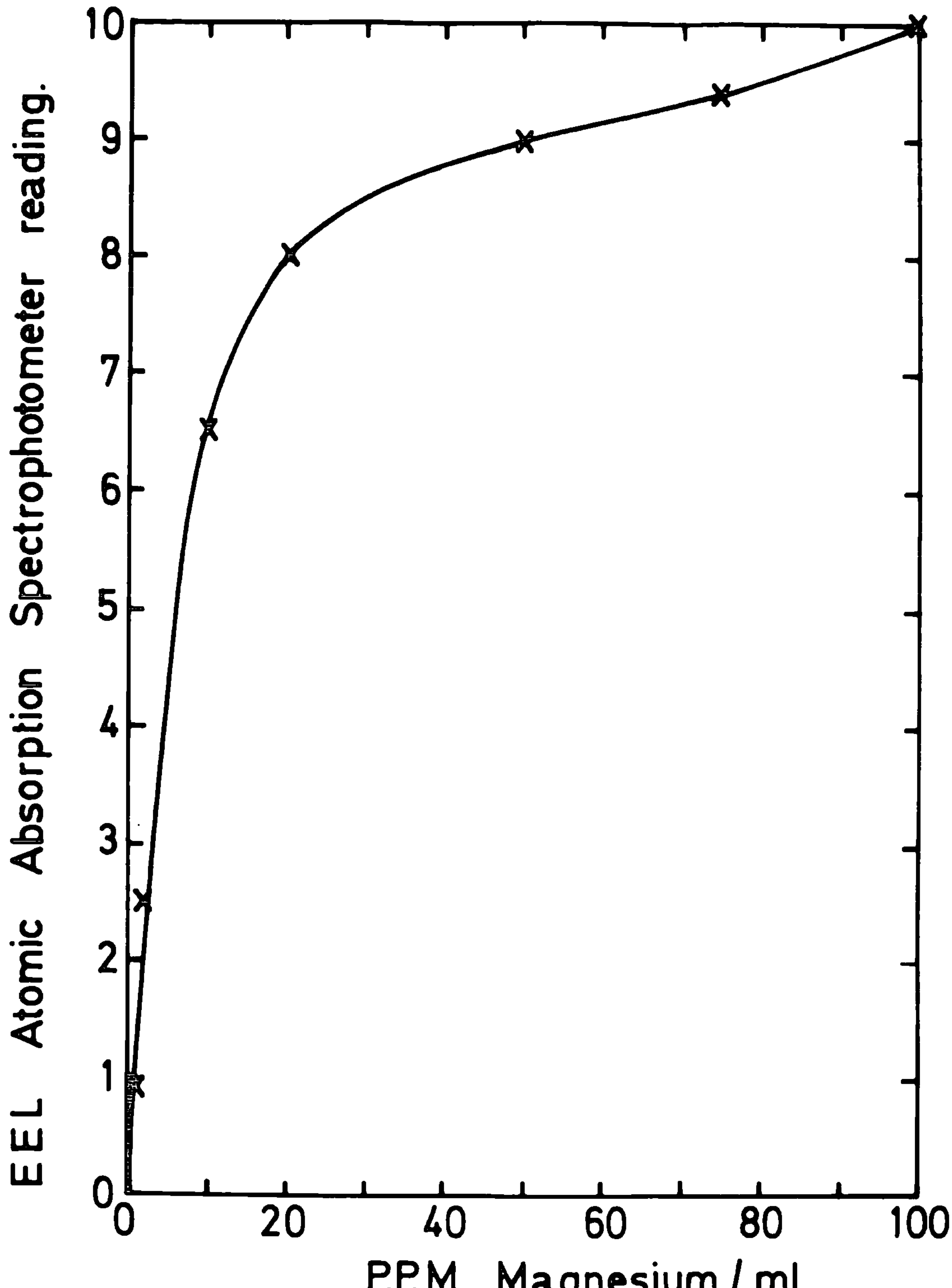


FIG. 64 Calibration Curve of Magnesium.
Full details table. A 14

16. Time Course investigation for NO_3-N and NH_3-N by micro diffusion (See plate 6)

The time course investigation were carried out using 5 micrograms of ammonia nitrogen and 5 micrograms for nitrate-nitrogen. The methods as used indicated that the highest level (colour sensitivity) was obtained for ammonia-nitrogen at 24.0 hours and 48 hours for nitrate-nitrogen.

The procedure was carried out at between 22-24°C. For details see Figs. 65 to 66 and all results are tabulated in Tables A15 and A16. (The way to develop the colours is described in estimation of nitrogen).

Table A 15

Time Course Investigation Data for Ammonia-Nitrogen. Standard prepared. See Nitrogen method. Wheel kept at constant temperature of 22-24°C.

Time (hr)	Reading
4	0.092
18	0.170
24	0.180
48	0.157
72	0.119

Table A 16

Time Course Investigation Data for Nitrate-Nitrogen. Standard prepared. See Also nitrogen method. Wheel kept at constant temperature of 22-24°C.

Time (hr)	Reading
3½	0.009
24	0.014
35	0.033
48	0.050
60	0.044
72	0.040

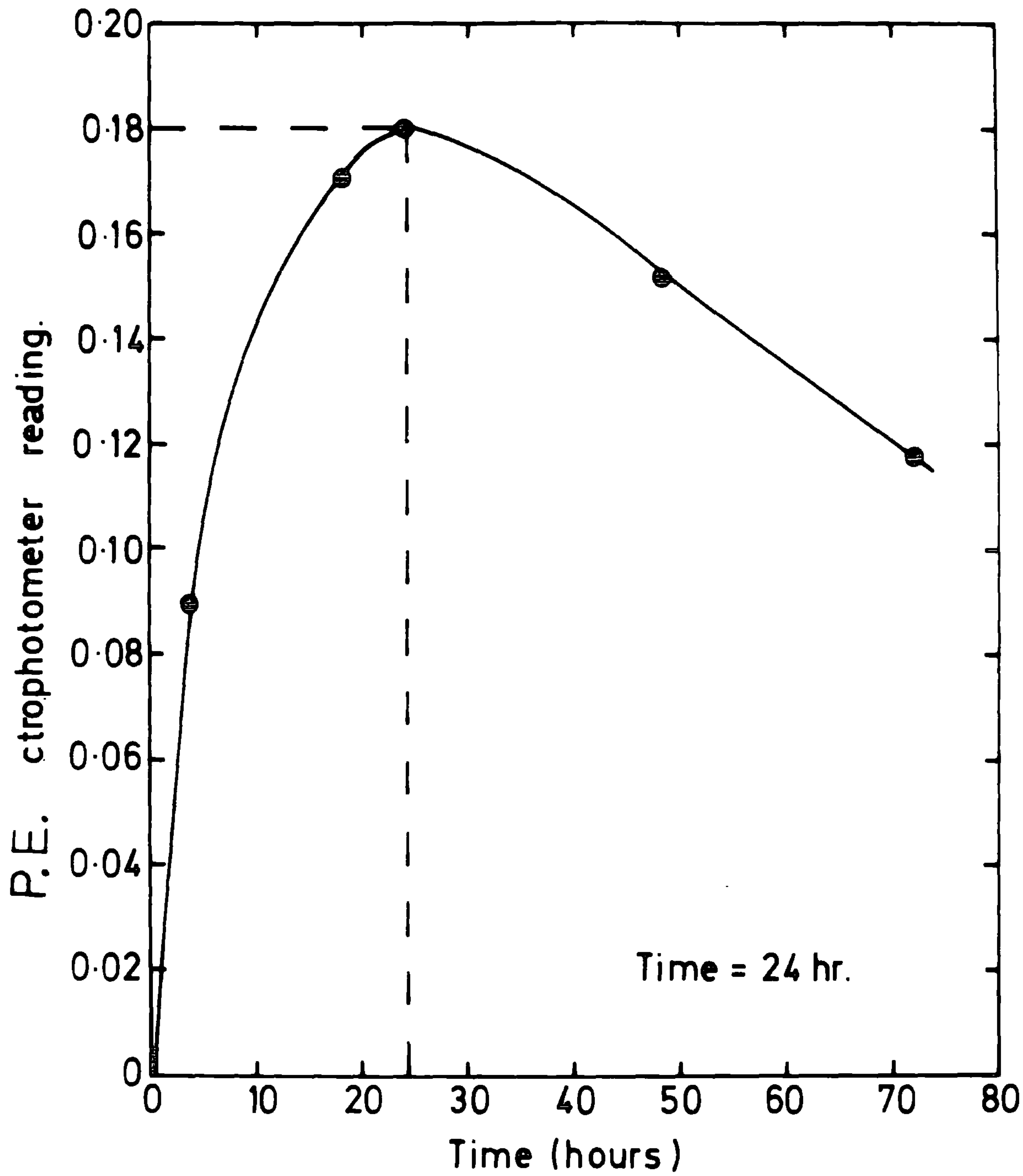


FIG. 65 Time Course investigations on cold distillation method for NH_3-N determination. Wheel kept at constant temperature of 22-24°C.

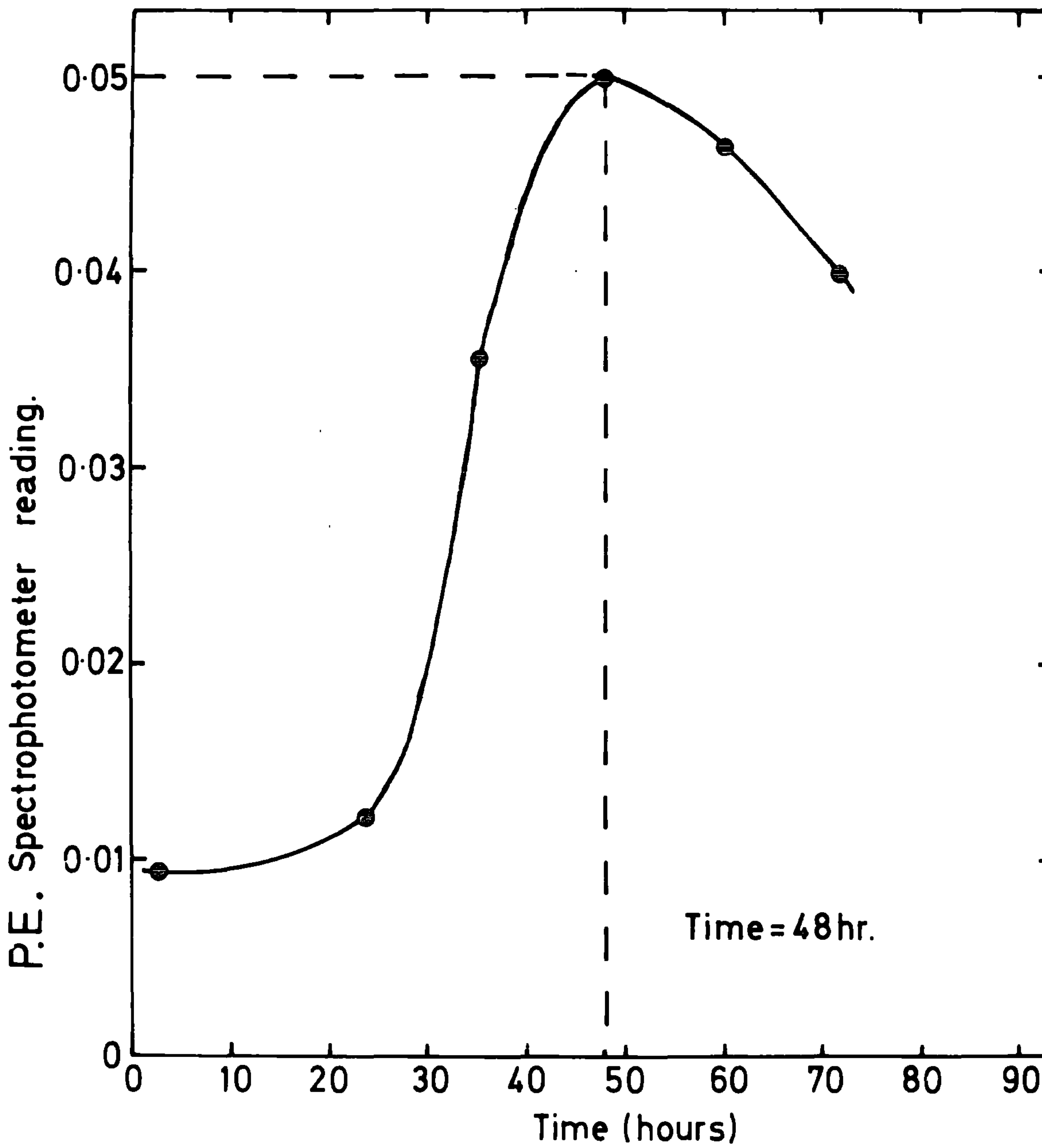


FIG. 66 Time Course investigations on cold distillation method for NO 3-N determination. Wheel kept at constant temperature of 22 - 24°C.

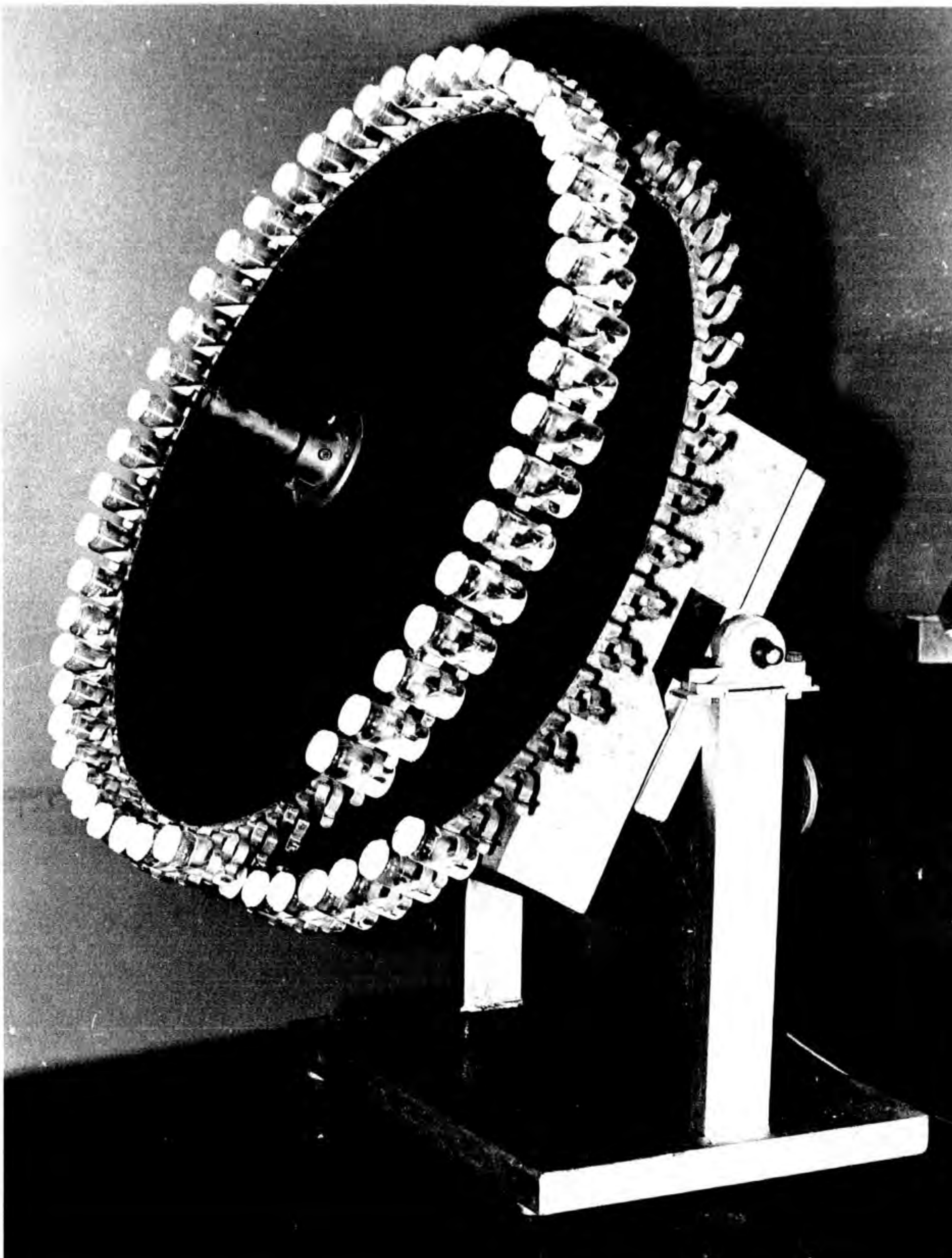


PLATE 6 Automated microConway.

TABLE I

Soil Organic Matter

Loss on Ignition in the three different field systems at
0-6 inch and 6-20 inch depths.
Change throughout the growing Season 1972.

Date	0-6 inch depth			0-20 inch depth		
	Organic	Mixed	Stockless	Organic	Mixed	Stockless
21. 3.72	5.9%	6.1%	4.7%	1.5%	2.7%	3.5%
1. 5.72	5.8	5.7	4.3	-	-	-
25. 6.72	4.7	5.2	4.4	5.7	5.2	4.2
10. 7.72	5.1	6.1	4.3	6.4	5.0	4.3
19. 8.72	6.8	6.0	4.8	6.5	5.9	4.5
20. 9.72	-	5.3	3.7	-	5.5	4.2
6.11.72	6.7	6.4	4.8	6.8	6.1	4.9
Mean	5.8	5.8	4.4	5.3	4.9	4.3

TABLE 2

Soil Analysis

Total organic nitrogen in the three different systems throughout the growing season 1972

Date	Organic Field	Mixed Field	Stockless Field
May 1972	1.980	1.760	1.078
June 1972	1.710	1.540	1.144
July 1972	1.540	1.562	1.012
August 1972	1.628	1.342	0.880
September 1972	1.562	1.188	0.968
Mean ± S.E	1.684 ± 0.078	1.478 ± 0.098	1.016 ± 0.10
St. Dev.	0.176	0.221	0.044

Test of Significance

Field Type	F	dif	P	R
O-M	12.890	8	3.35	*
O-S	8.234	5	4.47	*
M-S	4.574	5	4.47	*

All values in milligrams per gram dry soil.

S.E = Standard error.
St. Dev. = Standard deviations.
F = Variance ratio.
P = Probability value.
dif = Degrees of freedom.
R = Result of significance.
* = Significance difference at 5% level.

TABLE 3

Soil Analysis

Available phosphorus in the three different field systems throughout the growing season 1972

Date	Organic Field	Mixed Field	Stockless Field
May 1972	20.3	33.1	47.5
June 1972	20.0	58.0	79.5
July 1972	18.5	50.2	46.1
August 1972	30.0	45.6	32.3
September 1972	58.9	30.1	39.6
Mean ± S.E	29.54 ± 7.62	43.4 ± 5.23	49.00 ± 8.09
St. Dev.	17.03	11.696	18.084

Test of Significance

Field Type	t	P	R
O-M	2.179	2.26	*
O-S	2.393	"	*
M-S	1.130	"	N.S

All values in milligrams per gram air-dry soil.

S.E = Standard error.
St. Dev. = Standard deviation.
t = Students.
P = Probability value.

R = Result of significance.
* = Significance difference at 5%.
N.S = No significance difference

TABLE 4

Soil Analysis

Available potassium in the three different field systems throughout the growing season 1972

Date	Organic Field	Mixed Field	Stockless Field
May 1972	487.2	285.6	386.4
June 1972	436.8	386.4	420.0
July 1972	403.2	285.0	218.4
August 1972	420.0	202.4	202.4
September 1972	302.4	134.3	218.4
Mean ± S.E	409.92 ± 30.3	258.7 ± 42.6	289.12 ± 46.93
St. Dev.	67.83	95.35	105.02

Test of Significance

Field Type	t	P	R
O-M	2.895	2.306	*
O-S	2.399	"	*
M-S	1.218	"	N.S

All values in milligrams per gram air-dry soil.

S.E = Standard error
St. Dev. = Standard deviation
t = Students
P = Probability value

R = Result of significance
* = Significance difference at 5% level
N.S = No significance difference

TABLE 5

Soil Analysis

Total of K, Ca, Mg, Na, Cu and Zn, in the three different systems throughout the growing season 1972

Date	K	Ca	Mg	Na	Cu	Zn
	ORGANIC FIELD					
21. 3.72	3.125	18.50	1.920	0.188	0.036	0.075
1. 5.72	3.625	28.50	2.420	0.213	0.033	0.097
25. 6.72	3.380	26.60	2.000	0.188	0.022	0.097
10. 7.72	2.875	27.00	2.088	0.100	0.057	0.147
19. 8.72	3.040	16.40	1.696	0.214	0.031	0.093
20. 9.72	-	-	-	-	-	-
6.11.72	3.250	18.80	3.670	0.175	0.020	0.088
Mean ± S.E	3.22 ± 0.11	22.63 ± 2.16	2.297 ± 0.3	0.179 ± 0.01	0.033 ± 0.005	0.084 ± 0.02
St. Dev.	0.270	5.29	0.71	0.031	0.0132	0.048
	MIXED FIELD					
21. 3.72	2.375	17.30	2.75	0.075	0.036	0.078
1. 5.72	1.750	18.50	1.67	0.063	0.225	0.214
25. 6.72	2.750	17.80	1.92	0.100	0.014	0.111
10. 7.72	3.125	17.80	2.09	0.200	0.031	0.108
19. 8.72	3.750	16.10	2.25	0.213	0.013	0.086
20. 9.72	2.810	15.80	1.78	0.150	0.019	0.080
6.11.72	1.750	14.50	1.34	0.075	0.008	0.089
Mean ± S.E	2.62 ± 0.3	16.83 ± 0.5	1.79 ± 0.2	0.253 ± 0.13	0.049 ± 0.03	0.109 ± 0.02
St. Dev.	0.73	1.4	0.45	0.33	0.071	0.047
	STOCKLESS FIELD					
21. 3.72	2.125	22.50	1.50	0.075	0.026	0.122
1. 5.72	2.625	15.00	1.75	0.125	0.055	0.144
25. 6.72	3.250	14.80	1.92	0.163	0.024	0.163
10. 7.72	2.750	9.80	1.67	0.163	0.019	0.114
19. 8.72	2.000	11.80	1.42	0.063	0.013	0.136
20. 9.72	2.875	8.50	1.92	0.113	0.009	0.083
6.11.72	2.250	13.00	1.67	0.025	0.008	0.077
Mean ± S.E	2.53 ± 0.17	13.63 ± 1.74	1.69 ± 0.07	0.103 ± 0.02	0.049 ± 0.01	0.119 ± 0.011
St. Dev.	0.45	4.595	0.194	0.054	0.037	0.031

All concentrations as mg/g dry soil.

TABLE 6

Soil Analysis

Available phosphorus in the three different field systems throughout the growing Season 1973.
Soil collected in April.

No.	Organic	Mixed	Stockless
1	28.5	37.7	23.1
2	84.6	42.0	20.3
3	22.0	34.4	32.5
4	39.9	41.0	30.2
5	29.0	26.3	22.2
6	25.0	32.5	35.1
7	92.8	20.3	23.1
8	56.8	39.9	30.4
9	22.2	39.3	29.8
10	22.5	38.0	38.0
11	56.1	22.5	32.0
12	83.5	42.9	31.2
13	26.3	27.1	26.6
14	66.4	49.6	26.6
15	46.8	35.5	30.1
Mean ± S.E	46.8 ± 7.6	35.3 ± 2.3	28.8 ± 1.3
St. Dev.	26.1	8.5	5.0

All concentrations as microgram/one gram air-dry soil.

TABLE 7

Soil Analysis

Available phosphorus in the three different field systems throughout the growing Season 1973. Soil collected in May.

No.	Organic	Mixed	Stockless
1	26.0	38.8	22.0
2	62.5	36.1	20.3
3	49.1	36.1	23.1
4	42.3	37.4	40.7
5	36.9	34.7	32.3
6	49.1	27.9	26.6
7	57.2	25.2	34.6
8	65.4	38.8	36.7
9	62.7	33.4	26.6
10	70.8	40.1	27.9
11	52.2	37.4	23.9
12	52.2	36.1	22.2
13	52.2	22.5	19.8
14	52.2	27.9	20.9
15	52.2	32.0	29.8
Mean ± S.E	52.2 ± 4.5	33.6 ± 1.4	27.2 ± 1.7
St. Dev.	14.1	5.4	6.5

All concentrations as microgram/one gram air-dry soil.

TABLE 8

Soil Analysis

Available phosphorus in the three different field systems throughout the growing Season 1973.
Soil collected in July.

No.	Organic	Mixed	Stockless
1	67.0	41.5	27.1
2	48.0	27.9	28.5
3	37.2	30.6	27.1
4	38.5	27.9	25.8
5	42.6	23.9	23.1
6	64.3	34.7	19.0
7	80.6	26.6	23.1
8	50.7	22.5	21.7
9	34.4	29.3	21.7
10	71.1	40.3	20.3
11	56.1	72.7	21.7
12	65.6	45.6	23.1
13	65.6	32.0	23.5
14	65.6	32.0	23.5
15	65.6	34.8	23.5
Mean ± S.E	65.6 ± 7.2	34.8 ± 3.4	23.5 ± 0.9
St. Dev.	22.8	12.8	2.9

All concentrations as microgram/one gram air-dry soil.

TABLE 9

Soil Analysis

Available phosphorus in the three different field systems throughout the growing Season 1973.
Soil collected in September

No.	Organic	Mixed	Stockless
1	20.9	17.6	13.3
2	23.6	21.7	21.4
3	35.8	31.5	26.6
4	23.4	23.6	22.5
5	16.3	30.9	16.5
6	14.4	30.1	19.3
7	69.2	22.2	20.3
8	22.2	27.5	17.9
9	16.3	29.6	19.5
10	50.4	33.4	19.5
11	36.3	20.6	14.9
12	29.0	36.3	22.0
13	41.5	30.9	19.3
14	48.0	26.9	19.8
15	65.6	26.9	19.5
Mean ± S.E	34.9 ± 4.5	26.9 ± 1.6	19.5 ± 0.9
St. Dev.	17.3	5.8	3.3

TABLE 11

Soil Analysis

Available Potassium in the three different field systems throughout the growing season 1973. Soil collected in April.

No.	Organic	Mixed	Stockless
1	403.2	201.6	218.2
2	336.0	268.8	235.2
3	302.4	268.8	201.6
4	386.4	252.0	218.4
5	420.0	201.6	201.6
6	520.8	235.2	284.8
7	235.2	285.6	168.0
8	386.4	286.4	201.6
9	537.6	302.4	201.6
10	285.6	218.4	286.6
11	369.6	268.4	201.6
12	504.0	252.0	168.0
13	319.2	285.6	184.8
14	285.6	319.2	168.0
15		403.2	184.8
Mean ± S.E	378.0 ± 24.9	269.5 ± 15.2	208.32 ± 32.6
St. Dev.	93.15	85.85	32.6

All concentrations as microgram/one gram air-dry soil.

TABLE 12

Soil Analysis

Available Potassium in the three different field systems throughout the growing Season 1973.
Soil collected in May.

No.	Organic	Mixed	Stockless
1	470.4	134.3	168.0
2	436.8	235.2	134.3
3	302.4	168.0	151.2
4	319.2	184.8	117.6
5	336.0	184.8	117.6
6	285.6	151.2	117.6
7	571.2	151.2	134.6
8	252.0	151.2	134.6
9	252.0	168.0	100.8
10	420.0	201.6	100.8
11	218.4	134.3	117.6
12	403.2	168.0	134.3
13	319.2	218.4	134.3
14	352.8	134.3	134.3
15	201.6	151.2	151.2
Mean ± S.E	342.7 ± 26.9	169.3 ± 8.1	129.9 ± 4.8
St. Dev.	104.2	30.8	18.5

All concentrations as microgram/one gram air-dry soil.

TABLE 13

Soil Analysis

Available Potassium in the three different field systems throughout the growing Season 1973. Soil collected in July.

No.	Organic	Mixed	Stockless
1	235.2	184.8	100.8
2	201.6	134.4	117.6
3	218.4	168.0	134.4
4	252.0	134.4	176.4
5	285.6	184.8	134.4
6	218.4	188.0	134.4
7	218.4	134.4	117.6
8	235.2	134.4	117.6
9	218.4	151.2	117.6
10	201.6	117.6	134.4
11	252.0	134.4	201.6
12		134.4	168.0
13		117.6	168.0
14		184.8	134.4
15		201.8	117.6
Mean ± S.E	230.6 ± 7.5	153.7 ± 7.0	138.3 ± 7.2
St. Dev.	25.0	27.3	27.8

All concentrations as microgram/one gram air-dry soil.

TABLE 14

Soil Analysis

Available Potassium in the three different field systems throughout the growing Season 1973.
Soil collected in September.

No.	Organic	Mixed	Stockless
1	201.6	168.0	100.8
2	168.0	168.0	117.6
3	168.0	134.4	117.6
4	184.4	134.4	117.6
5	134.6	168.0	117.6
6	134.6	100.8	134.4
7	184.4	134.4	117.6
8	168.0	100.8	117.6
9	184.4	134.4	100.8
10	184.4	151.2	100.8
11	168.0	151.2	117.6
12	184.4	151.2	117.6
13	168.0	117.6	100.8
14	168.0	117.6	117.6
15	184.4		134.4
Mean ± S.E	172.3 ± 4.7	127.69 ± 10.7	115.4 ± 2.8
St. Dev.	18.3	41.6	10.8

All concentrations as microgram/one gram air-dry soil.

TABLE 16

Soil Analysis

Available Ammonia-Nitrogen in the three different field systems throughout the growing Season 1973. Soil collected in April.

No.	Organic	Mixed	Stockless
1	8.5	6.6	5.0
2	16.1	7.4	3.3
3	6.2	5.4	5.0
4	8.3	5.0	5.0
5	9.1	5.8	3.7
6	14.9	8.3	2.5
7	9.9	7.4	4.1
8	7.0	6.6	5.4
9	7.4	5.8	3.7
10	7.0	5.8	12.8
11	9.1	5.4	3.7
12	7.4	6.3	4.1
13	9.2	6.3	3.3
14	9.1	6.3	5.4
15	9.2	6.3	5.0
Mean ± S.E	9.2 ± 0.9	6.3 ± 0.3	4.8 ± 0.6
St. Dev.	3.1	1.0	2.4

All concentrations as microgram/one gram air-dry soil.

TABLE 17

Soil Analysis

Available Ammonia-Nitrogen in the three different field systems throughout the growing season 1973. Soil collected in May.

No.	Organic	Mixed	Stockless
1	5.5	2.5	4.0
2	4.5	3.0	4.0
3	3.5	3.5	1.5
4	3.5	8.5	2.0
5	1.5	3.5	0.5
6	4.0	4.5	8.0
7	5.3	3.5	2.5
8	5.0	3.5	7.0
9	5.0	11.5	2.0
10	1.5	4.5	3.5
11	3.93	5.5	8.0
12	3.93	3.0	1.9
13	3.93	8.5	3.5
14	3.93	5.5	1.5
15	3.93	7.5	2.0
Mean ± S.E	3.93 ± 0.5	4.8 ± 0.5	3.46 ± 1.0
St. Dev.	1.5	1.9	2.40

All concentrations as microgram/one gram air-dry soil.

TABLE 18

Soil Analysis

Available Ammonia-Nitrogen in the three different field systems throughout the growing season 1973. Soil collected in July.

No.	Organic	Mixed	Stockless
1	4.8	3.2	10.0
2	0.2	0.0	11.2
3	2.1	9.0	4.0
4	1.8	5.0	6.2
5	5.8	3.0	9.5
6	4.1	6.0	14.5
7	0.0	2.8	1.2
8	1.1	1.5	5.5
9	0.2	0.0	8.0
10	6.9	0.5	3.5
11	3.2	0.5	5.9
12	4.0	3.8	7.9
13	2.5	3.8	10.5
14	0.0	3.8	6.99
13	2.61	3.8	6.99
Mean ± S.E	2.61 ± 0.5	3.8 ± 0.5	6.99 ± 1.0
St. Dev.	2.2	1.9	3.9

All concentrations as microgram/one gram air-dry soil.

TABLE 19

Soil Analysis

Available Ammonia-Nitrogen in the three different field systems throughout the growing season 1973. Soil collected in September.

No.	Organic	Mixed	Stockless
1	4.48	8.0	8.0
2	2.50	1.5	2.9
3	5.6	1.6	4.0
4	3.2	4.0	8.0
5	4.8	1.6	1.6
6	16.0	2.4	4.8
7	6.4	2.4	4.0
8	3.2	2.4	4.8
9	3.2	2.4	5.6
10	8.0	4.8	4.8
11	4.8	6.4	2.4
12	7.2	6.4	0.8
13	4.0	3.2	0.8
14	2.4	0.0	2.4
15	8.0	0.0	3.2
Mean ± S.E	5.6 ± 0.9	3.1 ± 0.6	3.9 ± 0.6
St. Dev.	3.4	2.4	2.2

All concentrations as microgram/one gram air-dry soil.

TABLE 21

Soil Analysis

Available Nitrate-Nitrogen in the three different field systems throughout the growing Season 1973. Soil collected in April.

No.	Organic	Mixed	Stockless
1	54.5	34.8	1.49
2	55.6	55.2	1.49
3	53.1	53.6	1.54
4	27.2	19.5	5.2
5	10.2	43.2	1.49
6	44.3	44.5	5.2
7	59.0	44.5	2.95
8	59.0	30.2	8.2
9	56.8	12.0	8.2
10	49.5	22.7	1.49
11	46.92	19.5	2.95
12	46.92	34.52	2.95
13	46.92	34.52	2.66
14	46.92	34.52	2.60
15	46.92	34.52	2.60
Mean ± S.E	46.92 ± 5.08	34.52 ± 4.4	3.60 ± 0.7
St. Dev.	16.03	14.73	2.54

All concentrations as microgram/one gram air-dry soil.

TABLE 22

Soil Analysis

Available Nitrate-Nitrogen in the three different field systems throughout the growing Season 1973. Soil collected in May.

No.	Organic	Mixed	Stockless
1	17.12	13.60	10.88
2	29.60	14.4	10.88
3	46.37	33.2	4.6
4	15.3	18.9	0.0
5	11.8	35.1	2.85
6	28.7	0.0	1.96
7	0.0	28.4	17.12
8	50.5	42.0	0.0
9	21.6	34.95	0.0
10	6.4	49.22	9.1
11	22.7	22.5	4.6
12	22.7	20.7	14.4
13	22.7	6.4	3.03
14	22.7	2.85	0.18
15	22.7	1.07	4.64
Mean ± S.E	22.7 ± 5.2	21.6 ± 3.9	5.62 ± 1.4
St. Dev.	16.3	15.4	5.6

All concentrations as microgram/one gram air-dry soil.

TABLE 23

Soil Analysis

Available Nitrate-Nitrogen in the three different field systems throughout the growing Season 1973. Soil collected in July.

No.	Organic	Mixed	Stockless
1	5.35	7.13	7.1
2	1.78	9.8	8.0
3	23.19	8.9	0.0
4	71.30	7.1	19.6
5	53.51	9.8	0.89
6	8.92	53.5	9.8
7	32.1	14.3	14.3
8	30.3	21.4	8.9
9	16.1	9.8	9.8
10	21.3	12.5	1.78
11	8.9	9.8	9.8
12	26.72	0.0	1.78
13	30.3	0.0	8.9
14	0.0	0.0	0.0
15	0.0	0.0	0.0
Mean ± S.E	21.98 ± 5.2	10.9 ± 3.4	6.7 ± 1.5
St. Dev.	20.2	13.2	5.9

All concentrations as microgram/one gram air-dry soil.

TABLE 24

Soil Analysis

Available Nitrate-Nitrogen in the three different field systems throughout the growing Season 1973. Soil collected in September.

No.	Organic	Mixed	Stockless
1	19.8	18.2	2.27
2	13.6	4.5	18.2
3	21.4	6.8	13.6
4	4.5	19.0	9.7
5	13.6	19.0	9.1
6	21.3	16.0	13.6
7	4.5	13.6	16.1
8	2.2	18.2	13.6
9	9.7	15.0	6.0
10	6.0	19.8	6.8
11	6.1	18.5	18.2
12	19.8	19.8	18.2
13	20.4	16.1	2.3
14	19.0	0.0	4.5
15	9.8	0.0	2.3
Mean ± S.E	5.6 ± 0.9	10.7 ± 1.8	10.3 ± 1.6
St. Dev.	3.4	7.1	6.0

All concentrations as microgram/one gram air-dry soil.

TABLE 27

Soil Analysis

Concentration of Total Geochemicals in three different field systems at the beginning and end of the growing Season 1973.

Field Details		Ca		Mg		K		Na		P		Zn		Pb		Fe		Cu		Al		Mn		N	
		B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E	B	E
Organic	Mean	19.7	19.08	1.84	2.14	2.58	3.09	0.112	0.21	0.59	0.70	0.088	0.084	0.034	0.034	2.16	1.88	0.052	0.018	21.7	22.7	0.28	0.23	1.68	1.67
	± S.E	0.4	0.432	0.02	0.015	0.21	0.2	0.03	0.04	0.05	0.041	0.02	0.0	0.0	0.0	0.01	0.0	0.0	0.0	5.0	6.3	0.02	0.013	0.1	0.078
Mixed	Mean	17.4	16.68	1.76	2.03	2.46	2.65	0.096	0.13	0.78	0.82	0.144	0.082	0.037	0.037	2.33	1.88	0.137	0.019	21.9	19.0	0.28	0.24	1.41	1.50
	± S.E	0.07	0.076	0.05	0.05	0.07	0.1	0.0	0.013	0.02	0.03	0.01	0.0	0.0	0.0	0.03	0.029	0.0	0.0	5.6	3.6	0.03	0.013	0.1	0.098
Stockless	Mean	13.4	12.43	1.39	1.68	2.00	2.25	0.113	0.16	0.67	0.67	0.069	0.074	0.035	0.027	1.95	1.53	0.044	0.016	18.5	17.0	0.25	0.21	1.04	0.72
	± S.E	2.0	0.046	0.09	0.05	0.07	0.064	0.0	0.03	0.04	0.013	0.01	0.0	0.0	0.0	0.01	0.024	0.01	0.01	4.8	3.0	0.1	0.0	0.1	0.1

All concentrations as mg/g dry soil.

Mean = Mean of five samples.

S.E = ± Standard errors.

B = Beginning of the Season.

E = End of the Season.

TABLE 28

Soil Analysis

Statistical analysis of significance between the different field systems in the concentration of the geochemicals

Field Types \ Nutrient Details	Potassium (K)			Calcium (Ca)			Magnesium (Mg)			Sodium (Na)			Copper (Cu)			Zinc (Zn)		
	t	P	R	t	P	R	t	P	R	t	P	R	t	P	R	t	P	R
O - M	7.30	2.21	*	14.36	2.21	*	2.06	2.21	N.S	113.0	2.21	*	2.18	2.21	*	1.045	2.21	N.S
O - S	2.24	"	*	4.74	"	*	12.5	"	*	2.13	"	N.S	2.18	"	*	4.174	"	*
M - S	2.13	"	N.S	1.80	"	N.S	6.25	"	*	36.3	"	*	1.00	"	N.S	4.36	"	*

t = Students'S
P = Probability value
R = Result of significance
* = Significance difference at 5% level
N.S = No significance difference

TABLE 34

Time course of Acetylene Reduction by Soil Micro-organisms in Different Types of Fields, from April to September 1973. Soils were incubated in an average 12°C, with 2.5 ml of 5% glucose

1973	Time (hr)	Dry weight (gram)	ORGANIC FIELD		MIXED FIELD		STOCKLESS FIELD		Soil Moisture Content		
			$\mu M\ C_2H_4/g$	Rate = $\mu M\ C_2H_4/g/hr$	$\mu M\ C_2H_4/g$	Rate = $\mu M\ C_2H_4/g/hr$	$\mu M\ C_2H_4/g$	Rate = $\mu M\ C_2H_4/g/hr$	Organic	Mixed	Stockless
	0	30	-	-	-	-	-	-			
	15	"	-	-	-	-	-	-			
	30	"	0.315 ± 0.05	0.0105	0.243 ± 0.3	0.0081	0.322 ± 0.09	0.0107			
	44	"	8.415 ± 3.2	0.1912	6.475 ± 1.0	0.1470	30.390 ± 4.5	0.0180	31.7%	27.2%	21.6%
April	53	"	18.745 ± 6.3	0.354	25.543 ± 0.5	0.4819	64.660 ± 6.8	1.2200			
	67	"	40.740 ± 2.3	0.648	73.720 ± 6.2	1.1002	67.900 ± 11.0	1.0130			
	75	"	106.050 ± 15.4	1.414	110.580 ± 10.1	1.4740	194.640 ± 13.0	2.5950			
	89	"	150.030 ± 20.3	1.685	193.345 ± 12.1	2.1724	339.500 ± 12.0	3.8160			
	141	"	1544.240 ± 44.6	10.952	1410.978 ± 45.6	8.5500	1850.000 ± 50.2	18.0000			
	150	"	137.080 ± 13.2	0.830	340.135 ± 30.6	1.7990	267.860 ± 20.3	1.5600			
	0	30	-	-	-	-	-	-			
	15	"	-	-	-	-	-	-			
	30	"	-	-	0.800 ± 0.4	0.020	5.000 ± 2.8	0.166			
	44	"	12.000 ± 1.4	0.270	11.578 ± 0.0	0.261	36.900 ± 0.64	0.830			
	53	"	26.200 ± 0.4	0.490	30.900 ± 2.1	0.580	73.700 ± 1.9	1.390	23.3%	21.95%	20.1%
June	67	"	124.300 ± 2.1	1.850	35.900 ± 0.2	0.500	193.800 ± 3.4	2.900			
	75	"	101.900 ± 9.0	1.400	59.000 ± 6.6	0.800	228.500 ± 4.1	3.000			
	85	"	168.300 ± 19.0	1.880	239.300 ± 19.3	2.700	403.600 ± 10.8	4.500			
	99	"	927.800 ± 43.2	9.600	551.200 ± 10.6	5.600	1477.500 ± 10.7	15.300			
	121	"	620.900 ± 30.9	5.100	500.200 ± 11.6	4.100	1187.200 ± 44.5	9.800			
	0	30	-	-	-	-	-	-			
	15	"	-	-	-	-	-	-			
	30	"	8.300 ± 1.3	0.300	6.500 ± 0.63	0.250	3.500 ± 0.7	0.130			
	44	"	11.200 ± 1.3	0.300	6.500 ± 0.63	0.160	65.970 ± 0.7	1.590			
	53	"	50.000 ± 1.2	0.900	198.450 ± 2.9	3.700	44.500 ± 20.0	0.800			
August	67	"	256.400 ± 3.7	3.700	292.600 ± 20.3	4.200	44.800 ± 3.7	0.600	19.2%	22.2%	19.1%
	75	"	485.000 ± 2.9	5.600	148.800 ± 5.0	1.700	105.300 ± 4.3	1.230			
	89	"	701.100 ± 7.7	6.400	408.500 ± 20.1	3.700	1077.300 ±132.5	9.800			
	141	"	669.200 ± 10.1	4.990	605.500 ± 30.7	4.500	556.900 ± 55.1	4.100			
	158	"	600.200 ± 11.2	3.800	350.506 ± 11.6	2.200	232.700 ± 8.4	1.470			
	0	30	-	-	-	-	-	-			
	15	"	16.800 ± 0.9	0.850	1.800 ± 0.7	0.090	0.800 ± 0.0	0.040			
	30	"	18.700 ± 1.07	0.730	3.600 ± 1.7	0.140	5.400 ± 0.8	0.220			
	44	"	28.300 ± 3.7	0.600	30.400 ± 5.0	0.620	16.960 ± 1.5	0.350			
	53	"	34.100 ± 0.54	0.590	53.970 ± 1.89	0.870	50.100 ± 3.1	0.800	12.3%	14.4%	13.9%
September	67	"	79.100 ± 17.7	0.800	169.500 ± 2.5	1.800	64.800 ± 5.6	0.640			
	75	"	247.000 ± 2.1	2.100	342.600 ± 10.5	2.900	77.900 ± 4.1	0.660			
	89	"	400.500 ± 28.8	3.200	540.300 ± 20.5	4.300	103.500 ± 4.1	0.830			
	141	"	846.600 ± 72.2	5.600	860.100 ± 45.3	5.700	164.800 ± 13.9	1.100			
	150	"	406.500 ± 29.0	3.000	505.100 ± 10.0	3.500	103.000 ± 4.5	1.000			

- Reading = Zero.

TABLE 35

Soil Nitrogen Fixation

Amount of Ethylene produced in the acetylene reduction by soil micro-organisms, and nitrogen fixed in the three different field systems (including test of significance.)

Date / Field type	April 1973	June 1973	August 1973	September 1973	Total µM C_2H_4/g/hr	µM Nitrogen fixed/g/hr per Season	Kg Nitrogen fixed/ha/ season
	µM C_2H_4/g/hr	µM C_2H_4/g/hr	µM C_2H_4/g/hr	µM C_2H_4/g/hr			
Organic	10.95 ± 0.7	9.60 ± 0.8	6.49 ± 0.13	5.60 ± 0.8	32.64	10.87	39.87
Mixed	5.50 ± 0.4	5.60 ± 0.2	4.50 ± 0.4	5.70 ± 0.5	21.30	7.10	25.98
Stockless	18.00 ± 0.3	15.30 ± 0.19	9.80 ± 2.1	1.10 ± 0.21	43.10	14.37	73.92

Test of Significance

Date 1973	O - M				O - S				M - S			
	F	d.f	P	R	F	d.f	P	R	F	d.f	P	R
April	11.72	3	9.12	*	30.99	2	19.25	*	53.80	2	19.25	*
June	8.4	2	19.25	N.S	2.38	2	19.25	N.S	18.45	4	6.95	*
August	6.11	3	9.12	N.S	2.72	1	224.6	N.S	15.89	3	9.12	*
September	6.18	3	9.12	N.S	4.76	2	19.25	N.S	14.77	3	9.12	*

F = Variance ratio
d.f = Degrees of freedom
P = Probability value

R = Result of significance
* = Significance at 5% level
N.S = No " " " "

TABLE 39

Total Losses of Nutrients from Individual Drainage Water Collected from Different Field Lysimeters from April 1972 to March 1973

Total Organic Nitrogen

ORGANIC FIELD

Date	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	12.19	1.01	1.28	1.59
1.5. 1972	1.82	0.25	3.00	0.24	57.88	7.67	127.20	10.46
22. 5.1972	-	-	2.39	0.58	-	-	225.48	55.33
22. 6.1972	0.72	-	4.80	0.78	86.16	-	156.86	26.46
25. 7.1972	2.54	0.08	1.80	0.76	64.62	2.12	45.79	20.14
19. 8.1972	1.41	-	4.71	0.90	37.37	-	124.82	23.85
19. 9.1972	4.64	0.36	4.84	1.64	98.37	7.63	103.29	34.77
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	4.80	4.42	4.62	4.62	22.55	220.24	19.59	22.04
21. 1.1973	4.50	1.16	4.50	-	155.25	59.02	214.65	-
22. 2.1973	4.52	2.88	4.62	2.40	143.74	88.53	146.92	76.32
6. 3.1973	4.54	0.81	4.81	0.76	144.37	2.49	158.06	23.36
Total water volume lost L/Lysim./year	29.54	10.01	40.09	12.73				
Total losses = mg/vol./Lysim.					822.5	388.71	1323.92	294.36
Total losses = Kg/ha/year					0.2	1.45	0.37	1.1

MIXED FIELD

Date	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	1.22	2.12	1.54	1.54
1.5. 1972	4.66	0.11	4.94	0.26	143.22	3.50	157.09	9.92
22. 5.1972	-	0.06	2.66	-	-	3.81	211.47	-
22. 6.1972	-	-	5.00	1.00	-	-	137.86	28.62
25. 7.1972	0.24	-	4.10	1.42	5.85	-	108.65	36.27
19. 8.1972	0.51	-	4.88	0.90	12.43	-	103.46	22.90
19. 9.1972	1.50	0.48	3.90	0.24	33.39	111.19	90.95	5.09
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	2.71	2.81	4.67	-	114.90	119.14	198.01	-
21. 1.1973	0.05	1.30	4.05	-	1.21	45.40	141.43	-
22. 2.1973	0.20	2.74	4.81	-	6.36	86.50	152.96	-
6. 3.1973	4.58	0.72	5.05	-	106.81	9.35	112.43	-
Total water volume lost L/Lysim./year	14.50	7.79	44.11	3.87				
Total losses = mg/vol./Lysim.					425.4	380.92	1415.85	104.35
Total losses = Kg/ha/year					0.12	1.43	0.39	0.39

STOCKLESS FIELD (Normal fertilizer)

Date	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	1.01	1.07	1.54	1.54
1.5. 1972	4.90	0.25	4.57	0.35	129.85	7.69	172.48	11.13
22. 5.1972	-	-	1.98	0.48	-	-	115.43	43.25
22. 6.1972	-	-	5.00	1.28	-	-	143.10	39.35
25. 7.1972	0.26	-	3.36	1.20	6.34	-	85.48	33.07
19. 8.1972	6.34	-	4.86	1.52	9.50	-	12.37	48.34
19. 9.1972	3.60	-	4.02	1.86	91.58	-	96.60	39.43
6.11.1972	-	-	-	0.20	-	-	-	4.24
10.12.1972	4.46	-	4.88	4.00	236.39	-	289.50	199.40
21. 1.1973	3.75	-	-	1.27	115.28	-	-	118.62
22. 2.1973	4.56	-	-	2.82	193.34	-	-	8.98
6. 3.1973	4.04	-	-	0.78	89.93	-	-	19.84
Total water volume lost L/Lysim./year	26.02	0.3	28.75	15.81				
Total losses = mg/vol./Lysim.					873.2	8.75	911.53	497.21
Total losses = Kg/ha/year					0.25	0.03	0.26	1.9

STOCKLESS FIELD (High fertilizer)

Date	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.01	0.05	0.05	1.54	1.92	1.60	1.87
1.5. 1972	2.66	0.04	2.60	0.61	112.78	1.11	88.19	17.46
22. 5.1972	-	-	1.06	0.62	-	-	133.98	47.90
22. 6.1972	-	-	4.93	1.38	-	-	167.23	157.80
25. 7.1972	4.90	-	4.90	2.60	80.66	-	124.66	63.39
19. 8.1972	0.44	-	4.92	0.92	0.92	-	114.73	22.43
19. 9.1972	3.62	-	1.18	1.62	92.09	-	28.65	41.21
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	3.94	3.36	4.48	3.96	208.82	153.15	251.67	96.62
21. 1.1973	3.68	1.18	4.90	1.34	149.99	52.51	233.73	62.50
22. 2.1973	-	2.44	4.88	2.66	-	103.46	206.91	107.15
6. 3.1973	3.20	0.81	4.80	0.74	20.36	24.04	142.96	19.84
Total water volume lost L/Lysim./year	22.49	13.88	38.7	16.78				
Total losses = mg/vol./Lysim.					667.2	336.2	1494.31	588.17
Total losses = Kg/ha/year					0.19	1.3	0.42	2.21

- No water samples collected from this lysimeter
S Shallow lysimeter
D Deep lysimeter

C Cropped lysimeter
F Fallow lysimeter

TABLE 38

Total Losses of Nutrients from Individual Drainage Water
Collected from Different Field Lysimeters from April 1972 to March 1973

Nitrate-Nitrogen

ORGANIC FIELD

Date	Lysimeter water volume: Cropped S	Cropped D	Fallow S	Fallow D	Conc. mg/vol./month: Cropped S	Cropped D	Fallow S	Fallow D
1. 4.1972	0.05	0.05	0.05	0.05	0.63	0.36	0.56	0.30
1. 5.1972	1.82	0.25	3.00	0.24	11.65	1.51	14.96	0.79
22. 5.1972	-	-	2.34	0.58	-	-	25.51	6.13
22. 6.1972	0.72	-	4.80	0.78	2.05	-	32.11	4.74
25. 7.1972	2.54	0.08	1.80	0.76	1.88	0.86	17.26	5.70
19. 8.1972	1.41	-	4.71	0.90	1.37	-	53.51	9.61
19. 9.1972	4.64	0.36	4.84	1.64	2.09	1.18	41.62	9.32
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	4.80	4.42	4.62	4.62	15.79	48.22	25.41	35.94
21. 1.1973	4.50	1.16	4.50	-	17.37	8.05	13.50	-
22. 2.1973	4.52	2.88	4.62	2.40	10.26	13.00	5.78	13.22
6. 3.1973	4.54	0.81	4.81	0.76	14.07	7.00	6.79	3.79
Total water volume lost L/Lysim./year	29.54	10.01	40.09	12.73				
Total losses = mg/vol./Lysim.					77.15	79.26	236.75	89.51
Total losses = Kg/ha/year					0.02	0-29	0.065	0.3

MIXED FIELD

Date	Lysimeter water volume: Cropped S	Cropped D	Fallow S	Fallow D	Conc. mg/vol./month: Cropped S	Cropped D	Fallow S	Fallow D
1. 4.1972	0.05	0.05	0.05	0.05	0.51	0.51	0.11	0.11
1. 5.1972	4.66	0.11	4.94	0.26	31.78	1.06	19.66	1.85
22. 5.1972	-	0.06	2.66	-	-	0.59	17.53	-
22. 6.1972	-	-	5.00	1.00	-	-	50.25	6.94
25. 7.1972	0.24	-	4.10	1.42	0.61	-	43.79	12.43
19. 8.1972	0.51	-	4.88	0.90	0.56	-	41.04	7.52
19. 9.1972	1.50	0.48	3.90	0.24	2.99	0.97	33.66	6.90
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	2.71	2.81	4.67	-	8.40	3.68	27.60	-
21. 1.1973	0.05	1.30	4.05	-	8.49	9.54	32.00	-
22. 2.1973	0.20	2.74	4.81	-	0.17	0.20	20.00	-
6. 3.1973	4.58	0.72	5.05	-	3.11	1.89	22.73	-
Total water volume lost L/Lysim./year	14.50	7.79	44.11	3.87				
Total losses = mg/vol./Lysim.					56.62	18.52	308.36	35.74
Total losses = Kg/ha/year					0.02	0.07	0.09	0.13

STOCKLESS FIELD (Normal fertilizer)

Date	Lysimeter water volume: Cropped S	Cropped D	Fallow S	Fallow D	Conc. mg/vol./month: Cropped S	Cropped D	Fallow S	Fallow D
1. 4.1972	0.05	0.05	0.05	0.05	0.49	0.28	0.32	0.20
1. 5.1972	4.90	0.25	4.57	0.35	34.25	2.26	10.26	2.81
22. 5.1972	-	-	1.98	0.48	-	-	21.29	0.65
22. 6.1972	-	-	5.00	1.28	-	-	5.10	5.38
25. 7.1972	0.26	-	3.36	1.20	0.89	-	7.63	8.32
19. 8.1972	0.34	-	4.86	1.52	0.09	-	5.54	5.81
19. 9.1972	3.60	-	4.02	1.86	1.44	-	1.37	7.81
6.11.1972	-	-	-	0.20	-	-	-	2.65
10.12.1972	4.46	-	4.88	4.00	5.58	-	8.30	25.69
21. 1.1973	3.75	-	-	1.27	2.14	-	-	7.43
22. 2.1973	4.56	-	-	2.82	7.75	-	-	6.49
6. 3.1973	4.40	-	-	0.78	1.62	-	-	0.40
Total water volume lost L/Lysim./year	26.02	0.30	28.75	15.81				
Total losses = mg/vol./Lysim.					53.24	2.54	59.79	73.00
Total losses = Kg/ha/year					0.02	0.01	0.02	0.27

STOCKLESS FIELD (High fertilizer)

Date	Lysimeter water volume: Cropped S	Cropped D	Fallow S	Fallow D	Conc. mg/vol./month: Cropped S	Cropped D	Fallow S	Fallow D
1. 4.1972	0.05	0.05	0.05	0.05	0.34	0.23	0.46	3.11
1. 5.1972	2.66	0.04	2.60	0.61	16.92	0.25	17.73	2.94
22. 5.1972	-	-	1.06	0.62	-	-	12.99	3.41
22. 6.1972	-	-	4.93	1.38	-	-	14.79	6.76
25. 7.1972	4.90	-	4.90	2.60	2.60	-	2.79	14.77
19. 8.1972	0.44	-	4.92	0.92	0.34	-	20.42	2.21
19. 9.1972	3.62	-	1.18	1.62	28.24	-	2.95	20.80
6.11.1972	-	-	-	0.28	-	-	-	0.92
10.12.1972	3.94	3.36	4.48	3.96	17.34	7.72	11.21	45.14
21. 1.1973	3.68	1.18	4.90	1.34	9.20	0.95	4.46	1.53
22. 2.1973	-	2.44	4.88	2.66	-	6.93	11.23	1.52
6. 3.1973	3.20	6.81	4.80	0.74	1.49	3.13	0.82	0.32
Total water volume lost L/Lysim./year	22.49	13.88	38.7	16.78				
Total losses = mg/vol./Lysim.					76.41	19.21	99.84	103.45
Total losses = Kg/ha/year					0.02	0.07	0.03	0.4

- No water samples collected from this lysimeter
S Shallow lysimeter
D Deep lysimeter
C Cropped lysimeter
F Fallow lysimeter

TABLE 39

Total Losses of Nutrients from Individual Drainage Water
<u>Collected from Different Field Lysimeters from April 1972 to March 1973</u>

<u>Potassium</u>

ORGANIC FIELD	Lysimeter water volume: Cropped S	Cropped D	Fallow S	Fallow D	Conc. mg/vol./month: Cropped S	Cropped D	Fallow S	Fallow D
1. 4.1972	0.05	0.05	0.05	0.05	0.64	0.10	0.34	0.13
1. 5.1972	1.82	0.25	3.00	0.29	8.19	0.38	22.50	0.31
22. 5.1972	-	-	2.39	0.58	-	-	19.89	0.59
22. 6.1972	0.72	-	4.80	0.07	1.80	-	51.84	0.55
25. 7.1972	2.54	6.08	1.80	0.76	12.70	0.08	17.64	0.49
19. 8.1972	1.42	-	4.71	0.99	13.40	-	16.49	0.54
19. 9.1972	4.64	0.36	4.84	1.14	52.43	1.73	22.27	2.13
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	4.80	1.42	4.62	4.62	32.78	4.42	19.86	4.62
21. 1.1973	4.50	1.16	4.50	-	17.10	2.09	3.15	-
22. 2.1973	4.52	2.88	1.62	2.40	15.82	2.59	20.79	3.12
6. 3.1973	4.54	0.81	4.10	6.76	13.62	0.82	18.28	0.46
Total water volume lost L/Lysim./year	29.54	10.01	40.09	12.73				
Total losses = mg/vol./Lysim.					169.03	12.20	213.05	13.41
Total losses = Kg/ha/year					0.05	0.05	0.09	0.05

MIXED FIELD	Lysimeter water volume: Cropped S	Cropped D	Fallow S	Fallow D	Conc. mg/vol./month: Cropped S	Cropped D	Fallow S	Fallow D
1. 4.1972	0.05	0.05	0.05	0.05	0.07	0.62	0.07	0.65
1. 5.1972	4.66	0.11	4.94	0.20	4.66	1.27	4.94	0.65
22. 5.1972	-	0.07	2.66	-	3.62	0.15	2.93	-
22. 6.1972	-	-	5.06	1.00	-	-	6.51	0.41
25. 7.1972	0.24	-	4.10	1.42	0.91	-	5.33	0.85
19. 8.1972	0.51	-	4.88	0.90	3.06	-	16.59	0.90
19. 9.1972	1.50	0.48	3.90	2.99	6.45	0.53	9.75	0.89
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	2.71	2.81	4.67	-	2.71	3.09	1.87	-
21. 1.1973	0.05	1.30	4.05	-	2.24	8.84	2.84	-
22. 2.1973	0.20	2.74	4.81	-	0.27	2.74	1.92	-
6. 3.1973	4.58	0.72	5.05	-	1.37	0.25	1.92	-
Total water volume lost L/Lysim./year	14.50	7.70	44.11	3.87				
Total losses = mg/vol./Lysim.					25.35	17.49	51.45	4.34
Total losses = Kg/ha/year					0.01	0.07	0.01	0.02

STOCKLESS FIELD (Normal fertilizer)	Lysimeter water volume: Cropped S	Cropped D	Fallow S	Fallow D	Conc. mg/vol./month: Cropped S	Cropped D	Fallow S	Fallow D
1. 4.1972	0.05	0.05	0.05	0.05	0.30	0.05	0.27	0.22
1. 5.1972	4.90	0.25	4.52	6.35	31.85	0.15	20.34	6.28
22. 5.1972	-	-	1.98	0.48	-	-	10.89	0.43
22. 6.1972	-	-	5.00	1.28	-	-	35.00	0.90
25. 7.1972	0.26	-	3.36	1.20	2.21	-	26.88	1.20
19. 8.1972	6.34	-	4.86	1.57	0.51	-	21.87	7.60
19. 9.1972	3.60	-	4.02	1.86	23.40	-	48.24	10.30
6.11.1972	-	-	-	0.20	-	-	-	0.56
10.12.1972	4.46	-	4.81	4.00	30.33	-	14.64	1.26
21. 1.1973	3.75	-	-	1.27	25.50	-	-	1.27
22. 2.1973	4.56	-	-	2.82	9.12	-	-	9.31
6. 3.1973	4.04	-	-	6.78	26.26	-	-	0.70
Total water volume lost L/Lysim./year	26.02	0.3	28.75	15.81				
Total losses = mg/vol./Lysim.					149.5	0.2	178.13	39.14
Total losses = Kg/ha/year					0.04	0.001	0.05	0.2

STOCKLESS FIELD (High fertilizer)	Lysimeter water volume: Cropped S	Cropped D	Fallow S	Fallow D	Conc. mg/vol./month: Cropped S	Cropped D	Fallow S	Fallow D
1. 4.1972	0.05	0.05	0.05	0.05	0.16	0.11	0.25	0.03
1. 5.1972	2.66	0.64	2.66	0.61	6.65	0.13	6.81	0.24
22. 5.1972	-	-	1.06	0.62	-	-	5.28	0.43
22. 6.1972	-	-	4.93	1.38	-	-	21.20	0.69
25. 7.1972	4.90	-	4.46	2.60	6.62	-	24.50	1.30
19. 8.1972	0.44	-	4.97	0.92	6.82	-	16.24	1.01
19. 9.1972	3.62	-	1.18	1.62	9.05	-	0.71	3.73
6.11.1972	-	-	-	0.28	-	-	-	0.56
10.12.1972	3.94	3.36	4.48	4.96	9.06	10.09	8.06	7.13
21. 1.1973	3.68	1.18	4.90	1.34	4.78	6.83	1.96	1.21
22. 2.1973	-	2.44	4.88	2.66	-	2.44	7.37	0.27
6. 3.1973	3.20	6.81	4.80	0.74	5.76	0.73	7.89	0.22
Total water volume lost L/Lysim./year	22.49	13.88	38.7	16.76				
Total losses = mg/vol./Lysim.					48.85	19.58	100.26	16.80
Total losses = Kg/ha/year					0.01	0.07	0.03	0.03

- No water samples collected from this lysimeter
S Shallow lysimeter
D Deep lysimeter

TABLE 40

Total Losses of Nutrients from Individual Drainage Water
Collected from Different Field Lysimeters from April 1972 to March 1973

Calcium

ORGANIC FIELD

Date	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	4.03	3.28	6.33	8.87
1. 5.1972	1.82	0.25	3.00	0.24	149.60	22.25	207.00	16.60
22. 5.1972	-	-	2.39	0.58	-	-	147.37	40.02
22. 6.1972	0.72	-	4.80	0.78	42.84	-	518.19	70.20
25. 7.1972	2.54	0.08	1.80	6.76	85.75	0.70	154.80	88.92
19. 8.1972	1.41	-	4.71	6.90	83.20	-	647.63	100.80
19. 9.1972	4.64	6.36	4.84	1.64	26.22	18.36	236.64	216.48
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	4.80	4.42	4.82	4.62	39.54	78.04	35.57	515.13
21. 1.1973	4.50	1.16	4.50	-	403.75	266.42	524.25	-
22. 2.1973	4.52	2.88	4.63	2.40	388.7	404.64	351.11	291.60
6. 3.1973	4.54	6.01	4.81	0.76	320.07	82.62	33.91	46.36
Total water volume lost L/Lysim./year	29.54	10.01	40.09	12.73				
Total losses = mg/vol./Lysim.					1543.7	876.3	2862.8	1345.0
Total losses = Kg/ha/year					0.43	3.3	0.81	5.2

MIXED FIELD

Date	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	3.43	8.56	3.35	20.34
1. 5.1972	4.66	0.11	4.94	0.26	35.65	16.56	40.26	20.20
22. 5.1972	-	0.66	2.66	-	-	3.96	179.55	-
22. 6.1972	-	-	5.00	1.00	-	-	682.50	95.50
25. 7.1972	0.24	-	4.10	1.42	12.48	-	459.50	181.05
19. 8.1972	0.51	-	4.88	6.90	24.23	-	514.72	89.55
19. 9.1972	1.50	0.98	3.90	0.24	172.50	25.94	304.20	80.56
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	2.71	2.81	4.67	-	269.45	349.85	471.67	-
21. 1.1973	0.05	1.30	4.05	-	-	80.60	232.80	-
22. 2.1973	0.20	2.74	4.81	-	27.50	170.00	305.44	-
6. 3.1973	4.58	0.72	5.05	-	199.23	21.00	-	-
Total water volume lost L/Lysim./year	14.50	7.00	44.11	3.87				
Total losses = mg/vol./Lysim.					744.46	670.5	3193.99	487.2
Total losses = Kg/ha/year					0.2	2.5	0.9	1.8

STOCKLESS FIELD (Normal fertilizer)

Date	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	3.63	0.38	3.38	0.27
1. 5.1972	4.90	0.25	4.57	0.35	382.20	18.37	334.48	24.68
22. 5.1972	-	-	1.98	0.49	-	-	14.65	424.86
22. 6.1972	-	-	5.00	1.28	-	-	370.00	115.20
25. 7.1972	0.26	-	3.36	1.20	10.66	-	305.76	127.80
19. 8.1972	6.34	-	4.86	1.52	14.11	-	330.48	307.80
19. 9.1972	3.60	-	4.02	1.86	174.60	-	444.21	449.19
6.11.1972	-	-	-	0.20	-	-	-	24.70
10.12.1972	4.46	-	4.88	4.00	211.85	-	280.60	112.36
21. 1.1973	3.75	-	-	1.27	196.04	-	-	152.90
22. 2.1973	4.56	-	-	2.82	269.04	-	-	305.47
6. 3.1973	4.04	-	-	0.78	206.04	-	-	58.11
Total water volume lost L/Lysim./year	26.02	0.3	28.75	15.81				
Total losses = mg/vol./Lysim.					1468.2	18.75	2083.6	2102.8
Total losses = Kg/ha/year					0.41	0.07	0.6	7.9

STOCKLESS FIELD (High fertilizer)

Date	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	2.95	2.63	2.65	2.33
1. 5.1972	2.66	0.04	2.60	0.61	227.43	0.13	234.00	28.79
22. 5.1972	-	-	1.06	0.62	-	-	108.80	47.74
22. 6.1972	-	-	4.93	1.38	-	-	364.82	135.24
25. 7.1972	4.90	-	4.90	2.60	20.31	-	490.00	253.50
19. 8.1972	0.44	-	4.92	0.92	19.40	-	555.96	95.60
19. 9.1972	3.62	-	1.18	1.62	235.30	-	86.14	123.43
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	3.94	2.27	4.48	3.96	195.04	258.72	117.04	265.32
21. 1.1973	3.68	1.19	4.90	1.34	180.30	129.87	247.50	88.44
22. 2.1973	-	2.44	4.80	2.66	-	34.77	363.56	111.70
6. 3.1973	3.20	6.81	4.80	0.74	188.80	9.84	300.60	403.20
Total water volume lost L/Lysim./year	22.49	13.88	38.7	16.76				
Total losses = mg/vol./Lysim.					1069.6	435.96	2937.1	1555.3
Total losses = Kg/ha/year					0.3	1.64	0.83	5.8

- No water samples collected from this lysimeter
S Shallow lysimeter
D Deep lysimeter

TABLE 41

Total Losses of Nutrients from Individual Drainage Water
Collected from Different Field Lysimeters from April 1972 to March 1973

Magnesium

	ORGANIC FIELD							
	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	0.24	6.20	0.18	0.16
1. 5.1972	1.82	0.25	3.00	0.24	10.56	0.95	15.00	0.48
22. 5.1972	-	-	2.34	0.58	-	-	12.87	1.74
22. 6.1972	0.77	-	4.80	0.78	1.14	-	33.60	2.73
25. 7.1972	2.54	0.09	1.80	0.76	6.13	0.32	18.80	2.51
19. 8.1972	1.41	-	4.71	6.90	3.53	-	27.32	1.62
19. 9.1972	4.64	0.36	4.84	1.64	15.31	1.44	29.23	7.05
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	4.80	4.42	4.62	4.62	24.10	32.66	13.86	13.86
21. 1.1973	4.50	1.17	4.50	-	15.75	2.33	15.75	-
22. 2.1973	4.57	2.88	4.62	2.40	16.75	9.13	15.71	7.44
6. 3.1973	4.54	6.82	4.81	0.76	14.53	2.59	15.39	2.96
Total water volume lost L/Lysim./year	29.54	10.01	40.09	17.73				
Total losses = mg/vol./Lysim.					108.04	55.6	197.7	40.6
Total losses = Kg/ha/year					0.03	0.2	0.1	0.2

	MIXED FIELD							
	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	0.19	0.18	0.27	0.19
1. 5.1972	4.16	0.11	4.94	0.26	18.64	0.67	22.23	0.88
22. 5.1972	-	0.66	2.66	-	-	0.63	10.64	-
22. 6.1972	-	-	5.00	1.00	-	-	29.00	3.80
25. 7.1972	0.22	-	4.10	1.42	0.55	-	9.43	3.80
19. 8.1972	6.51	-	4.88	0.90	1.02	-	21.96	3.80
19. 9.1972	1.50	0.98	3.90	0.25	8.25	4.74	14.82	2.84
6.11.1972	-	-	-	-	-	24.70	-	3.60
10.12.1972	2.71	2.82	4.67	-	10.30	3.77	14.01	-
21. 1.1973	6.05	1.30	4.05	-	6.80	6.80	13.37	-
22. 2.1973	0.20	2.74	4.81	-	0.60	0.92	12.99	-
6. 3.1973	4.56	6.72	5.05	-	18.78	0.93	11.99	-
Total water volume lost L/Lysim./year	14.5	7.7	49.11	3.87				
Total losses = mg/vol./Lysim.					58.3	43.3	160.7	18.9
Total losses = Kg/ha/year					0.02	0.21	0.5	0.1

	STOCKLESS FIELD (Normal fertilizer)							
	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	0.20	0.05	0.24	0.25
1. 5.1972	4.90	0.25	4.57	0.35	22.05	0.45	17.18	0.81
22. 5.1972	-	-	1.90	6.48	-	-	7.92	1.92
22. 6.1972	-	-	5.06	1.28	-	-	17.50	4.22
25. 7.1972	0.26	-	3.36	1.20	6.52	-	11.09	4.56
19. 8.1972	6.34	-	4.86	1.52	0.78	-	13.61	8.82
19. 9.1972	3.60	-	4.02	1.86	7.20	-	15.28	13.95
6.11.1972	-	-	-	0.20	-	-	-	0.76
10.12.1972	4.46	-	4.88	4.00	10.26	-	21.96	8.64
21. 1.1973	3.75	-	-	1.28	9.36	-	-	8.64
22. 2.1973	4.56	-	-	2.82	7.75	-	-	7.05
6. 3.1973	4.64	-	-	0.76	6.87	-	-	1.95
Total water volume lost L/Lysim./year	26.02	0.3	28.75	15.21				
Total losses = mg/vol./Lysim.					65.0	0.5	104.8	61.6
Total losses = Kg/ha/year					0.02	0.002	0.03	0.23

	STOCKLESS FIELD (High fertilizer)							
	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	0.17	0.05	0.01	0.10
1. 5.1972	2.66	0.04	2.60	0.61	7.98	0.13	11.44	1.64
22. 5.1972	-	-	1.06	0.62	-	-	0.40	14.26
22. 6.1972	-	-	4.93	1.30	-	-	16.27	3.86
25. 7.1972	4.90	-	4.90	2.60	7.23	-	21.07	9.10
19. 8.1972	6.44	-	4.92	0.92	0.79	-	17.22	2.58
19. 9.1972	3.62	-	1.18	1.62	7.24	-	3.30	4.54
6.11.1972	-	-	-	-	-	-	-	2.32
10.12.1972	3.94	3.36	4.48	3.96	5.91	11.09	14.78	7.92
21. 1.1973	3.68	1.19	4.90	1.34	6.62	2.36	8.82	2.68
22. 2.1973	-	2.44	4.80	2.66	-	10.04	19.52	3.99
6. 3.1973	3.20	6.81	4.80	6.74	5.44	2.35	14.32	1.15
Total water volume lost L/Lysim./year	22.99	13.88	38.70	16.76				
Total losses = mg/vol./Lysim.					41.4	26.02	127.2	54.0
Total losses = Kg/ha/year					0.01	0.10	0.04	0.20

- No water samples collected from this lysimeter
S Shallow lysimeter
D Deep lysimeter

TABLE 42

Total Losses of Nutrients from Individual Drainage Water
Collected from Different Field Lysimeters from April 1972 to March 1973

Sodium

Date	ORGANIC FIELD							
	Lysimeter water volume				Conc. Mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	0.64	0.81	0.65	1.76
1. 5.1972	1.82	6.25	3.00	6.29	21.48	2.65	30.60	2.83
22. 5.1972	-	-	2.39	0.58	-	-	28.55	7.95
22. 6.1972	0.72	-	4.86	0.07	4.32	-	57.60	11.15
25. 7.1972	2.54	6.08	1.80	0.76	14.48	6.85	20.88	12.69
19. 8.1972	1.41	-	4.71	6.90	39.88	-	57.46	12.87
19. 9.1972	4.64	1.64	4.84	1.64	46.40	2.74	35.24	31.49
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	4.80	4.42	4.62	4.62	54.94	42.43	49.90	37.42
21. 1.1973	4.50	1.16	4.50	-	50.40	12.53	45.00	-
22. 2.1973	4.52	2.88	-	2.46	43.84	29.37	-	24.48
6. 3.1973	4.54	0.82	4.10	6.76	33.14	6.80	35.11	5.70
Total water volume lost L/Lysim./year	29.54	10.01	40.09	12.73				
Total losses = mg/vol./Lysim.					309.52	98.17	360.99	125.51
Total losses = Kg/ha/year					0.09	0.37	0.1	0.3

Date	MIXED FIELD							
	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	0.38	0.82	0.55	0.20
1. 5.1972	4.66	0.11	4.94	0.20	32.62	0.90	35.66	1.72
22. 5.1972	-	6.06	2.66	-	-	0.90	159.60	-
22. 6.1972	-	-	5.06	1.00	-	-	37.00	5.60
25. 7.1972	0.24	-	4.10	1.42	1.34	-	36.34	11.22
19. 8.1972	6.51	-	4.88	0.90	-	3.84	29.29	6.75
19. 9.1972	1.50	0.48	3.90	2.99	14.25	3.84	206.70	6.82
6.11.1972	-	-	-	-	-	-	-	-
10.12.1972	2.71	2.81	4.67	-	10.30	21.08	30.36	-
21. 1.1973	0.05	1.30	4.65	-	10.53	11.05	20.25	-
22. 2.1973	6.20	2.74	4.81	-	0.82	11.97	9.62	-
6. 3.1973	4.58	6.72	5.05	-	12.82	1.98	-	-
Total water volume lost L/Lysim./year	14.50	7.70	44.11	3.87				
Total losses = mg/vol./Lysim.					83.08	56.38	535.37	32.35
Total losses = Kg/ha/year					0.02	0.2	0.15	0.12

Date	STOCKLESS FIELD (Normal fertilizer)							
	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	0.54	0.53	0.53	6.73
1. 5.1972	4.90	0.25	4.52	6.35	31.36	1.78	27.12	2.10
22. 5.1972	-	-	1.88	6.48	-	-	12.67	3.02
22. 6.1972	-	-	5.00	1.28	-	-	24.50	8.32
25. 7.1972	0.26	-	3.36	1.20	1.40	-	22.18	8.76
19. 8.1972	6.34	-	4.86	1.57	77.11	-	30.13	1.84
19. 9.1972	3.60	-	4.02	1.86	30.96	-	30.15	17.48
6.11.1972	-	-	-	0.20	-	-	-	2.00
10.12.1972	4.46	-	4.81	4.00	24.98	-	31.72	8.23
21. 1.1973	3.75	-	-	1.27	25.13	-	-	8.06
22. 2.1973	4.56	-	-	2.82	14.14	-	-	10.72
6. 3.1973	4.04	-	-	0.78	21.88	-	-	3.28
Total water volume lost L/Lysim./year	26.02	0.3	28.75	15.81				
Total losses = mg/vol./Lysim.					226.63	2.31	179.05	74.54
Total losses = Kg/ha/year					0.06	0.01	0.05	0.28

Date	STOCKLESS FIELD (High fertilizer)							
	Lysimeter water volume				Conc. mg/vol./month			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
1. 4.1972	0.05	0.05	0.05	0.05	0.73	0.45	0.56	0.36
1. 5.1972	2.66	6.64	2.66	0.61	12.77	0.41	13.00	1.89
22. 5.1972	-	-	1.06	0.62	-	-	9.44	3.97
22. 6.1972	-	-	4.93	1.38	-	-	29.59	8.97
25. 7.1972	4.90	-	4.46	2.66	12.34	-	32.34	18.20
19. 8.1972	6.44	-	4.97	6.97	2.16	-	32.47	10.69
19. 9.1972	3.62	-	1.18	1.62	82.08	-	5.90	2.24
6.11.1972	-	-	-	0.78	-	-	-	2.77
10.12.1972	3.94	3.36	4.48	4.96	31.91	30.24	34.05	7.24
21. 1.1973	3.68	1.18	4.90	1.34	19.87	10.86	25.48	7.48
22. 2.1973	-	2.44	4.88	2.66	-	12.20	35.14	7.45
6. 3.1973	3.20	6.81	4.80	0.74	12.48	4.29	30.12	3.02
Total water volume lost L/Lysim./year	22.49	13.88	38.70	16.76				
Total losses = mg/vol./Lysim.					174.34	58.45	218.98	74.28
Total losses = Kg/ha/year					0.05	0.22	0.06	0.28

-No water samples collected from this lysimeter
S Shallow lysimeter
D Deep lysimeter

TABLE 42A

Geochemical Balance Sheets

Total organic nitrogen balance sheet for one year lysimeter experiments in the three different field systems at Haughley, Suffolk.

INPUT

	Organic Field				Mixed Field				Stockless Field (Normal fertilizer)				Stockless Field (High fertilizer)			
	Cropped		Fallow		Cropped		Fallow		Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Precipitation	2.94	2.88	2.94	2.88	2.99	2.88	2.94	2.88	2.94	2.88	2.93	2.88	2.94	2.88	2.94	2.88
Chemical fertilizers	-	-	-	-	19.00	19.00	19.00	19.00	4.70	4.70	4.70	4.70	34.70	34.70	34.70	34.70
Organic fertilizers	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	-	-	-	-	-	-	-	-
Seeds	0.0012	0.0012	-	-	0.00122	0.00122	-	-	0.00114	0.00114	-	-	0.0012	0.0012	-	-
Nitrogen fixation	39.87	39.87	39.87	39.87	25.98	25.98	25.98	25.98	73.90	73.90	73.90	73.90	74.0	74.0	74.0	74.0
Total INPUT	74.8	74.8	74.8	74.8	80.1	80.1	80.1	80.1	96.1	96.1	96.1	96.1	111.7	111.6	111.6	111.6
OUTPUT																
Lysimeter outflow	0.20	1.45	0.37	1.10	0.12	1.43	0.39	0.39	0.25	0.03	0.26	1.90	0.19	1.3	0.42	2.21
Maximum uptake by crop	4.6	4.6	-	-	5.15	5.15	-	-	2.7	2.7	-	-	2.7	2.7	2.7	2.7
Removed at harvest	0.38	0.30	-	-	.25	0.25	-	-	0.193	0.193	-	-	0.49	0.49	-	-
Denitrification	54.9	54.9	54.9	54.9	24.4	24.4	24.4	24.4	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Total OUTPUT	55.49	56.70	55.20	56.00	24.80	26.00	24.80	24.80	5.30	5.10	5.20	6.80	5.6	6.5	5.3	7.1
+ Gains - Losses	19.2	18.1	19.4	18.7	49.3	54.0	55.3	55.3	90.9	90.8	91.2	89.3	106.1	105.1	106.3	104.5

S = Shallow lysimeters D = Deep lysimeters Results are in Kg/ha/year

TABLE 42B

<u>Geochemical Balance Sheets</u>

Nitrate-Nitrogen balance sheet for one year lysimeter experiments in the three different field systems at Haughley, Suffolk.

INPUT	Organic Field				Mixed Field				Stockless Field (Normal fertilizer)				Stockless Field (High fertilizer)			
	Cropped		Fallow		Cropped		Fallow		Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Precipitation	0.87	0.85	0.87	0.85	0.87	0.85	0.87	0.85	0.87	0.85	0.87	0.85	0.87	0.85	0.87	0.85
Chemical fertilizers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic fertilizers	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	-	-	-	-	-	-	-	-
Seeds	0.003	0.003	-	-	0.001	0.001	-	-	0.001	0.001	-	-	0.001	0.001	-	-
Nitrogen fixation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total INPUT	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	0.87	0.85	0.87	0.85	0.871	0.851	0.87	0.85
OUTPUT																
Lysimeter outflow	0.02	0.29	0.06	0.03	0.02	0.07	0.09	0.13	0.02	0.001	0.02	0.27	0.02	0.07	0.03	0.4
Maximum uptake by crop	4.6	4.6	-	-	1.14	1.14	-	-	0.64	0.64	-	-	0.64	0.64	-	-
Removal at harvest	0.49	0.49	-	-	0.23	0.23	-	-	0.05	0.05	-	-	0.25	0.25	-	-
Denitrification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total OUTPUT	0.51	0.78	0.06	0.30	0.25	0.30	0.09	0.13	0.07	0.05	0.02	0.27	0.27	0.32	0.03	0.4
+ Gains - Losses	4.0	3.7	4.4	4.5	4.2	4.2	4.4	4.3	0.8	0.8	0.8	0.6	0.6	0.5	0.8	0.45

S = Shallow lysimeters
D = Deep lysimeters

Results are in Kg/ha/year

TABLE 42c

Geochemical Balance Sheets

Nitrate balance sheet for one year lysimeter experiments in the three different field systems at Haughley, Suffolk.

INPUT

	Organic Field				Mixed Field				Stockless Field (Normal fertilizer)				Stockless Field (High fertilizer)			
	Cropped		Fallow		Cropped		Fallow		Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Precipitation	3.9	3.8	3.9	3.8	3.9	3.8	3.9	3.8	3.9	3.8	3.9	3.8	3.9	3.8	3.9	3.8
Chemical fertilizers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Organic fertilizers	**3.6**	**3.6**	**3.6**	**3.6**	**3.6**	**3.6**	**3.6**	**3.6**	-	-	-	-	-	-	-	-
Seeds	0.0131	0.0131	-	-	0.0012	0.0012	-	-	0.0032	0.0032	-	-	0.001	0.001	-	-
Nitrogen fixation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total INPUT	**7.5**	**7.4**	**7.5**	**7.4**	**7.5**	**7.4**	**7.5**	**7.4**	**3.9**	**3.8**	**3.9**	**3.8**	3.9	3.8	3.9	3.8
OUTPUT																
Lysimeter outflow	0.09	1.30	0.29	0.11	0.07	0.30	0.40	0.60	0.1	0.004	0.08	1.20	0.1	0.004	0.08	1.20
Maximum uptake by crop	12.9	12.9	-	-	4.0	4.0	-	-	2.9	2.9	-	-	0.64	0.64	-	-
Removed at harvest	2.39	2.39	-	-	1.02	1.02	-	-	0.21	0.21	-	-	0.25	0.25	-	-
Denitrification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total OUTPUT	2.50	3.60	0.29	0.11	1.09	1.32	0.40	0.60	0.31	0.21	0.08	1.20	0.35	0.254	0.08	1.20
+ Gains - Losses	**5.0**	**3.7**	**7.2**	**7.3**	**5.8**	**6.1**	**7.1**	**6.8**	**3.6**	**3.6**	**3.8**	**2.6**	3.5	3.5	3.8	6.6

S = Shallow lysimeters

D = Deep lysimeters

Results are in Kg/ha/year

TABLE 42$_D$

Geochemical Balance Sheets

Potassium balance sheet for one year lysimeter experiments in the three different field systems at Haughley, Suffolk.

INPUT

	Organic Field				Mixed Field			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
Precipitation	3.26	3.19	3.26	3.19	3.26	3.19	3.26	3.19
Chemical fertilizers	-	-	-	-	**72.9**	**72.9**	**72.9**	**72.9**
Organic fertilizers	**21.8**	**21.8**	**21.8**	**21.8**	**21.8**	**21.8**	**21.8**	**21.8**
Seeds	0.03	0.03	-	-	0.03	0.03	-	-
Nitrogen fixation	-	-	-	-	-	-	-	-
Total INPUT	**25.1**	**25.0**	**25.1**	**25.0**	**97.9**	**97.9**	**97.9**	**97.9**
OUTPUT								
Lysimeter outflow	0.05	0.05	0.06	0.05	0.01	0.07	0.01	0.02
Maximum uptake by crop	129.2	129.2	-	-	68.3	68.3	-	-
Removed at harvest	20.1	20.1	-	-	19.6	19.6	-	-
Denitrification	-	-	-	-	-	-	-	-
Total OUTPUT	20.20	20.06	0.06	0.05	19.60	19.67	0.01	0.02
+ Gains - Losses	**5 0**	**4.9**	**25.6**	**24.9**	**78.3**	**78.2**	**96.9**	**97.7**

	Stockless Field (Normal fertilizer)				Stockless Field (High fertilizer)			
	Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D
Precipitation	3.26	3.19	3.26	3.19	3.26	3.19	3.26	3.19
Chemical fertilizers	**72.9**	**72.9**	**72.9**	**72.9**	110.4	110.4	110.4	110.4
Organic fertilizers	-	-	-	-	-	-	-	-
Seeds	0.03	0.03	-	-	0.03	0.03	-	-
Nitrogen fixation	-	-	-	-	-	-	-	-
Total INPUT	**76.2**	**76.1**	**76.2**	**76.1**	113.6	113.7	113.7	113.6
OUTPUT								
Lysimeter outflow	0.04	0.01	0.05	0.14	0.01	0.07	0.03	0.03
Maximum uptake by crop	55.6	55.6	-	-	55.6	55.6	-	-
Removed at harvest	7.3	7.3	-	-	7.3	7.3	-	-
Denitrification	-	-	-	-	-	-	-	-
Total OUTPUT	7.30	7.30	0.05	0.14	7.31	7.37	0.03	0.03
+ Gains - Losses	**68.9**	**68.8**	**76.2**	**75.9**	106.3	106.3	113.7	113.6

S = Shallow lysimeters
D = Deep lysimeters

Results are in Kg/ha/year

TABLE 42ᴇ

Geochemical Balance Sheets

Magnesium balance sheet for one year lysimeter experiments in the three different field systems at Haughley, Suffolk.

INPUT

	Organic Field				Mixed Field				Stockless Field (Normal fertilizer)				Stockless Field (High fertilizer)			
	Cropped		Fallow		Cropped		Fallow		Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Precipitation	4.51	4.35	4.51	4.35	4.51	4.35	4.51	4.35	4.51	4.35	4.51	4.35	4.51	4.35	4.51	4.35
Chemical fertilizers	-	-	-	-	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Organic fertilizers	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	-	-	-	-	-	-	-	-
Seeds	0.01	0.01	-	-	0.01	0.01	-	-	0.01	0.01	-	-	0.01	0.01	-	-
Nitrogen fixation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total INPUT	18.4	18.4	18.4	18.3	19.5	19.4	19.5	19.4	5.6	5.6	5.6	5.5	5.62	5.5	5.6	5.6
OUTPUT																
Lysimeter outflow	0.09	0.37	0.10	0.47	0.02	0.21	0.15	0.12	0.06	0.009	0.05	0.28	0.05	0.22	0.06	0.28
Maximum uptake by crop	4.6	4.6	-	-	5.3	5.3	-	-	2.7	2.7	-	-	2.7	2.7	-	-
Removed at harvest	3.29	3.29	-	-	2.67	2.67	-	-	1.93	1.93	-	-	1.93	1.93	-	-
Denitrification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total OUTPUT	3.40	3.66	0.10	0.47	2.90	2.90	0.15	0.12	1.99	1.94	0.05	0.28	1.98	2.2	0.06	0.28
+ Gains - Losses	15.0	14.6	18.3	17.8	16.8	16.5	19.4	19.3	3.6	3.7	5.6	5.2	3.6	3.4	5.5	5.2

S = Shallow lysimeters
D = Deep lysimeters

Results are in Kg/ha/year

TABLE 42F

Geochemical Balance Sheets

Calcium balance sheet for one year lysimeter experiments in the three different field systems at Haughley, Suffolk.

INPUT	Organic Field				Mixed Field				Stockless Field (Normal fertilizer)				Stockless Field (High fertilizer)			
	Cropped		Fallow		Cropped		Fallow		Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Precipitation	7.51	7.36	7.51	7.36	7.51	7.36	7.51	7.36	7.51	7.36	7.51	7.36	7.51	7.36	7.51	7.36
Chemical fertilizers	-	-	-	-	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Organic fertilizers	73.8	73.8	73.8	73.8	73.8	73.8	73.8	73.8	-	-	-	-	-	-	-	-
Seeds	0.006	0.006	-	-	0.005	0.005	-	-	0.0053	0.0053	-	-	0.005	0.005	-	-
Nitrogen fixation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total INPUT	81.3	81.2	81.3	81.2	84.6	84.5	84.6	84.5	10.8	10.7	10.7	10.7	10.8	10.7	10.7	10.7
OUTPUT																
Lysimeter outflow	0.43	3.30	0.81	5.20	0.20	0.20	0.90	1.80	0.40	0.07	6.00	7.90	0.3	1.64	0.83	5.8
Maximum uptake by crop	27.6	27.6	-	-	36.4	36.4	-	-	23.7	23.7	-	-	23.7	23.7	-	-
Removed at harvest	41.19	41.19	-	-	21.47	21.47	-	-	21.53	21.53	-	-	21.5	21.5	-	-
Denitrification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total OUTPUT	41.50	41.60	0.81	5.20	21.70	23.97	0.90	1.80	22.10	21.60	0.60	7.90	21.5	23.1	0.83	5.8
+ Gains	39.7	36.7	80.5	76.0	62.9	63.0	83.7	82.7			10.1	2.9			9.9	4.9
- Losses									11.1	10.9			11.0	12.4		

S = Shallow lysimeters
D = Deep lysimeters

Results are in Kg/ha/year

TABLE 42$_G$

Geochemical Balance Sheets

Sodium balance sheet for one year lysimeter experiments in the three different field systems at Haughley, Suffolk.

INPUT	Organic Field				Mixed Field				Stockless Field (Normal fertilizer)				Stockless Field (High fertilizer)			
	Cropped		Fallow		Cropped		Fallow		Cropped		Fallow		Cropped		Fallow	
	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Precipitation	5.06	4.95	5.06	4.95	5.06	4.95	5.06	4.95	5.06	4.95	5.06	4.95	5.06	4.95	5.06	4.95
Chemical fertilizers	-	-	-	-	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Organic fertilizers	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	-	-	-	-	-	-	-	-
Seeds	0.011	0.011	-	-	0.01	0.01	-	-	0.024	0.024	-	-	0.02	0.02	-	-
Nitrogen fixation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total INPUT	8.5	8.4	8.5	8.4	9.6	9.5	9.6	9.6	6.2	6.1	6.2	6.1	6.2	6.1	6.2	6.1
OUTPUT																
Lysimeter outflow	0.09	0.37	0.10	0.50	0.02	0.20	0.20	0.12	0.06	0.01	0.05	0.28	0.05	0.22	0.06	0.28
Maximum uptake by crop	23.1	23.1	-	-	4.1	4.1	-	-	4.1	4.1	-	-	4.1	4.1	-	-
Removed at harvest	4.1	4.1	-	-	5.8	5.8	-	-	0.51	0.51	-	-	0.51	0.51	-	-
Denitrification	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total OUTPUT	4.19	4.10	0.10	0.50	5.80	6.00	0.20	0.12	0.57	0.52	0.05	0.28	0.6	0.6	0.06	0.28
+ Gains - Losses	4.3	3.9	8.4	7.9	3.8	3.5	9.7	9.5	5.6	5.6	6.2	5.8	5.6	5.5	6.1	5.8

S = Shallow lysimeter
D = Deep lysimeter

Results are in Kg/ha/year

TABLE 44

Concentration of Nitrate Nitrogen, Nitrate and Organic Nitrogen as:-

*amount of the nutrients extracted by the crop (short-term storage) at maximum uptake;

**amount of the nutrients removed at normal harvest.

Date	Organic System			Mixed System			Stockless System		
	NO_3-N	NO_3	N_2	NO_3-N	NO_3	N_2	NO_3-N	NO_3	N_2
1.5.72	0.0014	0.0065	0.0066	0.0010	0.0045	0.0037	0.00124	0.0055	0.0041
22.5.72	0.0146	0.0648	0.0506	0.0066	0.0292	0.0506	0.0165	0.0732	0.0419
22.6.72	0.2140	0.9481	0.3939	0.0982	0.4347*	0.5621*	0.0707*	0.3135*	0.2930*
10.7.72	0.31983	1.4170*	0.5071*	0.0870	0.3855	0.3781	0.0437	0.1933	0.2389
25.7.72	0.4146	0.6678	0.3898	0.1249*	0.0952	0.2497	0.0337	0.1494	0.1892
19.8.72	0.5106*	0.8221	0.4016	0.0282	0.1246	0.2346	0.0170	0.0739	0.2153
19.9.72	0.0549**	0.2656**	0.0427**	0.0256**	0.1132**	0.0278**	0.0052**	0.0231**	0.0214**
Total amounts g/100 Plants/ season	1.5299	4.1919	1.7923	0.3715	1.1869	1.4782	0.188	0.8319	1.0038

All concentrations based on g/100 Plants.

TABLE 45

Concentration of Potassium, Phosphorus and Calcium as:-

*amount of the nutrients extracted by the crop (short-term storage) at maximum uptake;

**amount of the nutrients removed at normal harvest.

Date	Organic System			Mixed System			Stockless System		
	P	K	Ca	P	K	Ca	P	K	Ca
1.5.72	0.0017	0.0377	0.0125	0.0012	0.0231	0.0086	0.0014	0.0283	0.0087
22.5.72	0.0073	0.2189	0.2465	0.0088	0.0745	0.2496	0.0058	0.5695	0.2583
22.6.72	0.0523	2.2991	1.6184	0.0739*	4.4138	3.9642*	0.0799*	3.6223	2.6101*
10.7.72	0.0676	8.5146	2.1476	0.0614	7.4750*	2.8909	0.0332	5.1863	2.4273
25.7.72	0.0829*	12.6197	2.1149	0.0389	6.3737	1.7642	0.0599	6.0807*	1.8257
19.8.72	0.0120	14.1645*	3.0289*	0.0500	5.0393	1.3741	0.0440	4.5494	1.2538
19.9.72	0.0366**	2.2318**	4.5736**	0.0237**	2.1676**	2.3858**	0.0245**	0.8069**	2.3925**

All concentrations based on g/100 Plants.

TABLE 46

Concentration of Magnesium and Sodium as:-

*amount of the nutrients extracted by the crop (short-term storage) at maximum uptake;

**amount of the nutrients removed at normal harvest.

Date	Organic System		Mixed System		Stockless System	
	Mg	Na	Mg	Na	Mg	Na
1.5.72	0.00485	0.00526	0.00191	0.00314	0.00436	0.00142
22.5.72	0.04458	0.06842	0.02174	0.05504	0.01681	0.02426
22.6.72	0.06129	1.9503	0.58427*	1.4792	0.30446*	0.43918*
10.7.72	0.32810	1.5662	0.40510	1.48538	0.27646	0.20015
25.7.72	0.49073	2.5356*	0.36084	1.58082*	0.28735	0.15324
19.8.72	0.51049*	1.53162	0.30415	0.98849	0.29357	0.07584
19.9.72	0.36586**	0.45484**	0.29638**	0.64515**	0.21438**	0.05632*

All concentrations based on g/100 Plants.

TABLE 50a

Data recorded are the Dry Weights of Organic Seeds

34.55	25.10	26.00	22.85
35.15	32.00	28.95	40.35
37.15	34.05	34.90	32.65
36.35	49.05	19.00	39.00
44.65	27.10	34.60	32.10
44.40	29.20	39.15	32.70
30.95	40.55	36.75	40.15
44.10	29.75	36.50	22.40
27.35	51.20	27.40	36.75
60.00	23.55	30.90	35.15
36.00	42.70	34.90	53.85
40.00	24.50	20.00	27.50
37.55	45.20	30.45	24.35
28.95	37.55	32.20	26.65
29.10	48.55	32.50	20.90
36.20	33.10	45.05	26.00
23.85	36.33	27.80	28.05
34.25	30.00	25.85	37.10
24.55	27.95	19.15	43.65
28.75	42.20	41.05	29.50
25.40	41.65	20.55	28.25
34.90	53.45	20.00	45.66
34.55	31.95	41.20	33.10
41.25	30.80	33.20	19.35
39.90	43.15	37.65	36.66

Seeds were selected randomly from the stock.

All weights in milligrams.

TABLE 50_b

Data recorded are the Dry Weights of Mixed Seeds

38.45	39.20	35.50	37.45
39.55	41.00	30.75	24.35
32.75	42.70	37.10	32.20
34.35	40.50	40.55	36.60
32.05	41.65	32.40	34.85
36.10	36.65	33.60	30.06
29.60	45.85	42.95	36.35
30.70	36.85	44.55	43.45
40.40	36.70	27.20	33.20
28.60	34.70	40.00	46.30
35.55	31.40	33.75	40.00
28.25	34.70	34.55	38.35
31.20	35.05	38.20	32.20
39.20	33.05	37.55	35.95
40.55	31.65	35.50	35.90
35.00	38.00	34.20	30.40
37.60	33.35	35.00	32.20
32.20	33.50	38.95	40.00
42.50	40.00	33.75	34.45
31.80	33.40	32.25	13.00
22.50	38.65	30.00	32.15
36.25	36.95	42.25	30.05
29.30	39.45	32.85	31.05
32.45	32.00	24.50	36.66
34.50	29.65	31.54	27.95

Seeds were selected randomly from the stock.

All weights in milligrams.

TABLE 50c

Data recorded are the Dry Weights of Stockless Seeds

33.70	38.45	30.25	40.20
37.00	32.30	31.40	31.40
33.30	30.55	30.15	29.95
31.40	23.85	40.60	23.25
33.15	33.10	36.85	41.40
35.30	36.80	21.80	33.50
36.80	32.95	20.40	32.00
40.80	36.10	35.20	33.10
25.15	34.15	34.15	36.30
39.00	36.30	25.65	37.85
35.00	40.90	35.70	33.70
30.60	26.70	36.55	37.05
26.55	25.80	33.90	36.30
32.65	41.25	21.20	26.85
41.45	43.30	35.20	36.35
34.20	23.40	34.25	42.90
42.10	33.90	43.45	35.05
30.00	31.55	27.80	33.70
31.70	33.70	25.00	27.95
30.20	24.70	26.70	35.55
24.35	15.60	26.70	27.15
33.05	37.15	35.15	34.95
34.30	36.90	30.00	26.65
26.70	36.05	32.35	20.45
35.80	42.20	29.10	38.75

Seeds were selected randomly from the stock.

All weights in milligrams.

TABLE 50d

Data recorded are the Imbibed Weights of Organic Seeds

70.30	51.30	61.54	67.15
60.45	69.70	46.90	66.40
85.65	51.25	69.45	68.60
58.05	67.45	72.15	61.65
58.75	48.25	69.35	52.35
39.20	61.00	43.35	81.55
71.50	62.45	50.50	64.50
64.15	51.50	52.90	66.85
72.00	61.85	53.95	55.15
63.15	91.10	44.00	51.85
60.00	52.95	72.35	54.00
57.85	64.65	42.15	62.35
54.80	69.66	51.25	34.95
63.05	73.00	77.10	43.46
60.35	58.76	64.05	65.50
64.75	57.45	61.66	67.40
66.25	85.35	55.75	62.50
56.46	70.86	48.20	57.15
55.55	70.30	56.26	57.95
62.00	78.56	78.40	51.95
78.45	55.20	39.35	54.75
43.30	66.20	55.50	55.90
72.10	80.00	50.35	57.15
73.50	54.65	54.00	48.65
50.00	68.70	54.10	61.90

Seeds were selected randomly from the stock.

All weights in milligrams.

TABLE 50e

Data recorded are the Imbibed Weights of Mixed Seeds

74.95	63.15	65.95	66.60
86.55	48.70	65.10	70.80
70.75	66.55	57.30	66.20
69.45	66.15	62.62	56.95
61.30	56.50	60.00	68.40
55.25	61.90	47.90	52.45
53.60	67.15	56.70	63.80
48.10	55.60	58.00	52.00
62.60	53.40	56.90	62.35
41.20	65.85	57.46	66.70
50.55	52.40	57.20	71.55
55.00	51.75	46.35	67.25
55.00	56.05	53.35	54.85
50.85	64.65	70.00	62.20
51.30	56.95	57.75	61.80
77.50	62.60	61.55	62.25
61.70	59.25	68.65	64.00
39.45	51.00	63.20	64.30
52.75	53.15	52.70	56.60
71.50	63.25	67.75	62.70
62.65	51.55	43.95	66.95
55.35	53.90	39.40	50.60
58.20	65.55	58.35	76.05
70.10	48.95	66.05	60.60
70.00	60.06	63.35	53.75

Seeds were selected randomly from the stock.

All weights in milligrams.

TABLE 50f

Data recorded are the Imbibed Weights of Stockless Seeds

54.25	59.05	66.05	61.20
80.00	37.35	56.15	49.95
75.06	66.10	49.95	67.15
60.95	48.45	51.10	66.55
44.46	57.05	63.05	61.20
60.05	56.00	50.75	60.10
58.33	47.50	77.25	47.00
54.15	58.10	54.00	68.65
54.15	58.45	61.15	63.00
57.75	55.00	72.15	69.05
51.45	43.35	66.55	69.10
65.90	68.35	72.00	49.35
57.95	57.50	62.80	42.60
46.15	67.30	71.85	52.00
56.10	59.50	57.00	52.20
76.25	50.00	61.65	54.75
77.15	50.55	71.10	66.70
64.00	47.30	63.50	51.20
54.06	73.95	72.25	60.00
58.85	47.40	67.37	52.80
60.25	59.50	51.25	52.20
62.60	49.15	62.25	63.00
60.00	65.75	63.80	57.25
61.35	79.25	60.46	56.05
53.90	72.10	62.65	65.00

Seeds were selected randomly from the stock.

All weights in milligrams.

TABLE 60

Plant Growth Curves

Regression Equations for all four plant types grown on Organic Field

	Organic Plants				Mixed Plants			
First variable	-6.1993	$+1.5421^{T}$	$\pm 6.7032^{T^2}$	$\pm 8.9437^{T^3}$	-8.9129	$+3.3153^{T}$	$\pm 3.5928^{T^2}$	$+1.2204^{T^3}$
S.E. of Coeff.	1.4669	8.0689	1.2618	5.8972	2.1348	1.1743	1.8364	8.8268
Second variable	7.5676	$+1.0598^{T}$	$\pm 9.3409^{T^2}$	$+2.5673^{T^3}$	4.7882	$+1.2117^{T}$	$\pm 1.1767^{T^2}$	$+2.8295^{T^3}$
S.E. of Coeff.	1.1218	6.1708	9.3689	4.5099	7.8752	4.3319	6.7742	3.1660
	d.f	SS log W	S product	SS log A	d.f	SS log W	S product	SS log A
Linear	1	1.6392	6.4179	2.5128	1	1.1476	1.2243	1.3062
Quadratic	1	4.3893	1.9851	8.9775	1	5.3737	3.2581	1.9755
Cubic	1	3.3641	-9.6569	2.7721	1	6.2642	1.4498	3.3552
Residual between	3	4.3876	3.2475	2.5663	3	9.2942	2.1226	1.2667
Total.	6	13.7802	1.9936	16.8287	6	22.0797	8.0548	7.9036

	Stockless Plants				Sultan Plants			
First variable	-4.5400	$+4.0633^{T}$	$+1.3742^{T^2}$	$\pm 1.3101^{T^3}$	-4.6252	$+4.5009^{T}$	$+1.2843^{T^2}$	$\pm 1.0760^{T^3}$
S.E. of Coeff.	8.5903	4.7527	7.3891	3.4535	2.0509	1.1281	1.7642	8.2450
Second variable	3.6794	$+1.2398^{T}$	$\pm 1.1726^{T^2}$	$+3.3231^{T^3}$	7.0356	9.1987^{T}	$\pm 6.7382^{T^2}$	$+1.1651^{T^3}$
S.E. of Coeff.	1.5033	8.2691	1.2931	6.0435	7.8379	4.1135	6.7421	3.1510
	d.f	SS log W	S product	SS log A	d.f	SS log W	S product	SS log A
Linear	1	1.6585	5.4950	1.8206	1	1.7287	6.3706	2.3183
Quadratic	1	6.2663	2.8474	1.2939	1	5.9306	2.5294	1.0789
Cubic	1	5.3800	-1.5807	4.6445	1	4.8681	-5.2724	3.7093
Residual between	3	1.5048	2.0596	4.6083	3	8.5772	1.1322	1.2527
Total.	6	14.8096	8.8213	12.3673	6	21.1047	4.7598	8.3592

TABLE 60A

Plant Growth Curves

Regression Equations for all four plant types grown on Stockless soil without N.P.K.

	Organic Plants				Mixed Plants			
First variable	-4.63390	$+4.5436^{T}$	$+1.2785^{T2}$	$\pm1.0735^{T3}$	-8.2573	$+2.7930^{T}$	$\pm2.6228^{T2}$	$+7.9416^{T3}$
S.E. of Coeff.	2.0491	1.1271	1.7626	3.2377	2.2547	1.2403	1.9395	9.0645
Second variable	7.0356	$+9.1987^{T}$	$\pm6.7382^{T2}$	$+1.1651^{T3}$	-2.6603	$+1.5687^{T}$	$\pm1.6938^{T2}$	5.5008^{T3}
S.E. of Coeff.	7.8378	1.3114	6.7421	3.1510	1.4390	7.3924	1.1560	5.4028
	d.f	SS log W	S product	SS log A	d.f	SS log W	S product	SS log A
Linear	1	1.7297	6.3324	2.3183	1	1.4225	3.8194	1.0255
Quadratic	1	5.9382	2.5310	1.0788	1	5.3214	2.9549	1.6408
Cubic	1	4.8465	-5.2602	5.7093	1	2.6542	1.8379	1.2725
Residual between	3	8.5621	1.1289	1.2527	3	1.0367	6.0882	3.6829
Total.	6	21.0765	4.7321	10.3591	6	10.4348	14.7004	7.6217

	Stockless Plants				Sultan Plants			
First variable	-8.9128	$+3.3153^{T}$	$\pm3.5428^{T2}$	$+1.2204^{T3}$	-8.0755	$+2.4973^{T}$	$\pm2.6331^{T2}$	$+5.0426^{T3}$
S.E. of Coeff.	2.1349	1.1743	1.8365	8.5626	2.5590	1.4076	2.2012	1.0288
Second variable	4.7882	+1.2117	±1.1764	+2.8245	4.8694	+9.9266	±5.8865	±8.9643
S.E. of Coeff.	7.8752	4.3319	6.7742	3.1660	1.3246	7.2860	1.1394	5.3353
	d.f	SS log W	S product	SS log A	d.f	SS log W	S product	SS log A
Linear	1	1.1476	1.2243	1.3062	1	1.8296	1.2649	8.7448
Quadratic	1	5.3737	3.2581	1.9755	1	5.5046	4.4456	3.5904
Cubic	1	6.2642	1.4498	3.3552	1	1.0694	-1.8974	3.3661
Residual between	3	9.2942	2.1226	1.2697	3	1.3354	5.3071	3.5781
Total.	6	22.0797	8.0548	7.9066	6	9.7390	9.1202	19.2794

TABLE 60g

Plant Growth Curves

Regression Equations for all four plant types grown on Stockless field with 3 cwt. N.P.K.

	Organic Plants				Mixed Plants			
First variable	-7.4881	+2.3922^{T}	±2.0659^{T2}	+5.5511^{T3}	-8.4209	+2.8781^{T}	±2.8076^{T2}	+9.0120^{T3}
S.E. of Coeff.	1.6145	8.8870	1.3888	6.4907	1.9865	1.6927	1.7080	7.9863
Second variable	8.1799	+1.1457^{T}	±1.0741^{T2}	+2.1550^{T3}	+5.1559	+1.2588^{T}	±1.2274^{T2}	+2.9828^{T3}
S.E. of Coeff.	1.5163	8.3407	1.3643	6.0959	1.7972	9.8061	1.5461	7.2253
	d.f	SS log W	S product	SS log A	d.f	SS log W	S product	SS log A
Linear	1	1.4081	3.0469	6.5933	1	1.5477	1.5130	1.4791
Quadratic	1	4.6632	3.2428	2.2550	1	1.7286	3.1467	2.0939
Cubic	1	1.2960	5.0312	1.9532	1	3.4210	1.1314	3.7418
Residual between	3	5.3156	-3.8423	1.6855	3	8.0473	5.5975	6.5889
Total.	6	12.6829	7.4987	12.4870	6	14.7446	11.3886	13.9037

	Stockless Plants				Sultan Plants			
First variable	-6.4230	+1.6873^{T}	±9.2972^{T2}	+4.3806^{T3}	-7.8009	+2.5539^{T}	±2.2089^{T2}	+5.8601^{T3}
S.E. of Coeff.	1.6714	5.8937	9.2167	4.3074	2.2195	1.2209	1.9025	8.9230
Second variable	3.1307	+1.3645^{T}	±1.5159^{T2}	+4.9192^{T3}	-1.6752	+2.5916^{T}	±3.4036^{T2}	1.3294^{T3}
S.E. of Coeff.	9.3931	5.1669	8.6800	3.7762	1.7016	9.3603	1.4638	6.8410
	d.f	SS log W	S product	SS log A	d.f	SS log W	S product	SS log A
Linear	1	1.6562	2.2869	3.1576	1	1.3323	1.2176	1.1125
Quadratic	1	4.1529	2.3400	1.3185	1	5.6681	3.3705	2.0043
Cubic	1	8.0707	9.0631	1.7994	1	1.1149	3.2429	7.4326
Residual between	3	2.3410	1.6502	1.7992	3	1.6046	4.9103	3.4012
Total.	6	16.2208	15.3402	8.0747	6	9.7199	12.7413	13.9506

TABLE 60$_c$

Plant Growth Curves

Regression Equations for all four plant types grown on Stockless Field with 5 cwt. N.P.K.

	Organic Plants				Mixed Plants			
First variable	-7.0980	+2.2418^T	±2.0951$^{T^2}$	+7.0579$^{T^3}$	-8.5125	+2.9131^T	±2.8003$^{T^2}$	+8.6671$^{T^3}$
S.E. of Coeff.	2.0747	1.1413	1.7847	8.3411	2.2696	1.2484	1.9523	91.243
Second variable	-9.2956	+2.0813^T	±2.4900$^{T^2}$	+9.2291$^{T^3}$	-1.4574	+2.4209^T	±3.0972$^{T^2}$	+1.1901$^{T^3}$
S.E. of Coeff.	1.5019	8.2615	1.2919	6.6379	1.1601	6.3833	9.9823	4.6052
	d.f	SS log W	S product	SS log A	d.f	SS log W	S product	SS log A
Linear	1	1.7667	4.8262	1.3184	1	1.4676	2.6041	4.6209
Quadratic	1	2.1118	1.8778	1.6698	1	5.4694	3.1536	1.8181
Cubic	1	2.6951	2.7740	3.5823	1	3.1594	4.3674	6.0372
Residual between	3	8.7783	4.8714	4.5998	3	1.0504	5.3180	2.7461
Total	6	15.3519	14.3494	11.1703	6	11.1468	15.4431	15.2223

	Stockless Plants				Sultan Plants			
First variable	-6.0069	+1.5849^T	±5.3511$^{T^2}$	±3.1299$^{T^3}$	-7.0623	+2.0861^T	±1.5877$^{T^2}$	+3.5746$^{T^3}$
S.E. of Coeff.	2.3093	1.2702	1.9861	9.2836	1.9403	1.6673	1.6091	7.8607
Second variable	9.4277	+1.4581^T	+1.5535$^{T^2}$	±5.1109$^{T^3}$	-2.1268	+1.9020^T	±2.2535$^{T^2}$	7.6992$^{T^3}$
S.E. of Ceoff.	1.0563	5.8105	9.0865	4.2460	1.5040	8.2734	1.2937	6.0466
	d.f	SS log W	S product	SS log A	d.f	SS log W	S product	SS log A
Linear	1	8.1150	3.4555	1.4130	1	1.6365	1.1530	8.1242
Quadratic	1	8.5364	3.3325	1.7010	1	4.0741	3.0424	2.2719
Cubic	1	4.1201	-6.7279	1.0986	1	5.3748	1.1576	2.4931
Residual between	3	1.0875	3.0072	2.2754	3	7.6777	1.9881	4.6130
Total	6	21.8590	3.0673	6.4880	6	18.7631	7.3411	17.5022

TABLE 61

Plant Growth Curves

Four plants growing on Organic soil

(a) Dry Weight

Plant type \ Regression Equation	Linear				Quadratic				Cubic				Total			
	F	P		R	F	P		R	F	P		R	F	P		R
		20%	5%			20%	5%			20%	5%			20%	5%	
O - M	1.333	9.5	161.5	N.S	1.227	9.5	161.5	N.S	0.294	9.5	161.5	N.S	2.265	2.1	4.3	**
O - S	1.063	"	"	N.S	1.432	"	"	N.S	1.588	"	"	N.S	1.521	"	"	N.S
O - Su	1.063	"	"	N.S	1.341	"	"	N.S	1.139	"	"	N.S	2.143	"	"	**
M - S	1.417	"	"	N.S	1.167	"	"	N.S	1.167	"	"	N.S	1.490	"	"	N.S
M - Su	1.417	"	"	N.S	1.093	"	"	N.S	1.286	"	"	N.S	1.057	"	"	N.S
S - Su	1.00	"	"	N.S	1.068	"	"	N.S	1.102	"	"	N.S	1.457	"	"	N.S

(b) Leaf Area

O - M	1.923	9.5	161.5	N.S	4.500	9.5	161.5	N.S	1.214	9.5	161.5	N.S	2.000	2.1	4.3	N.S
O - S	1.389	"	"	N.S	6.923	"	"	N.S	1.643	"	"	N.S	1.336	"	"	N.S
O - Su	1.087	"	"	N.S	8.182	"	"	N.S	1.321	"	"	N.S	1.940	"	"	N.S
M - S	1.385	"	"	N.S	1.538	"	"	N.S	1.069	"	"	N.S	1.525	"	"	N.S
M - Su	1.769	"	"	N.S	1.818	"	"	N.S	1.088	"	"	N.S	1.077	"	"	N.S
S - Su	1.277	"	"	N.S	0.909	"	"	N.S	1.243	"	"	N.S	1.452	"	"	N.S

F = Variance ratio
P = Probability value
R = Result of significance

** = Significance at 20% level
N.S = No significance either at 5% or 20% level

TABLE 61A

Plant Growth Curves

Four plants growing on Stockless soil without fertilizers

(a) Dry Weight

Plant Type \ Regression Equation	Linear				Quadratic				Cubic				Total			
	F	P		R	F	P		R	F	P		R	F	P		R
		20%	5%			20%	5%			20%	5%			20%	5%	
O - M	1.214	9.5	161.5	N.S	1.113	9.5	161.5	N.S	1.178	9.5	161.5	N.S	2.023	2.1	4.3	N.S
O - S	1.545	"	"	N.S	1.093	"	"	N.S	1.313	"	"	N.S	1.052	"	"	N.S
O - Su	1.058	"	"	N.S	1.073	"	"	N.S	4.364	"	"	N.S	2.211	"	"	**
M - S	1.273	"	"	N.S	1.019	"	"	N.S	2.332	"	"	N.S	2.129	"	"	**
M - Su	1.286	"	"	N.S	1.038	"	"	N.S	2.455	"	"	N.S	1.095	"	"	N.S
S - Su	1.636	"	"	N.S	1.019	"	"	N.S	5.722	"	"	N.S	2.326	"	"	**

(b) Leaf Area

Plant Type	Linear F	P 20%	P 5%	R	Quadratic F	P 20%	P 5%	R	Cubic F	P 20%	P 5%	R	Total F	P 20%	P 5%	R
O - M	1.923	9.5	161.5	N.S	1.455	9.5	161.5	N.S	3.385	9.5	161.5	N.S	1.362	2.1	4.3	N.S
O - S	1.818	"	"	N.S	1.812	"	"	N.S	1.676	"	"	N.S	1.301	"	"	N.S
O - Su	3.78	"	"	N.S	3.272	"	"	N.S	1.676	"	"	N.S	1.859	"	"	N.S
M - S	1.300	"	"	N.S	1.250	"	"	N.S	2.615	"	"	N.S	1.005	"	"	N.S
M - Su	8.700	"	"	N.S	2.250	"	"	N.S	2.615	"	"	N.S	2.549	"	"	**
S - Su	6.69	"	"	N.S	1.800	"	"	N.S	1.000	"	"	N.S	2.413	"	"	**

F = Variance ratio
P = Probability value
R = Result of significance

** = Significance at 20% level
N.S = No significance either at 5% or 20% level

TABLE 61 B

Plant Growth Curves

Four plants growing on Stockless soil with 3 cwt./N.P.K.

(a) Dry Weight

Plant Type \ Regression Equation	Linear				Quadratic				Cubic				Total			
	F	P		R	F	P		R	F	P		R	F	P		R
		20%	5%			20%	5%			20%	5%			20%	5%	
O - M	0.357	9.5	161.5	N.S	2.063	9.5	161.5	N.S	1.509	9.5	161.5	N.S	1.909	9.5	2.1	N.S
O - S	1.213	"	"	N.S	1.119	"	"	N.S	6.230	"	"	N.S	1.283	"	"	N.S
O - Su	1.077	"	"	N.S	1.213	"	"	N.S	1.182	"	"	N.S	1.395	"	"	N.S
M - S	1.333	"	"	N.S	1.133	"	"	N.S	2.189	"	"	N.S	1.098	"	"	N.S
M - Su	1.154	"	"	N.S	1.213	"	"	N.S	1.100	"	"	N.S	1.697	"	"	N.S
S - Su	1.307	"	"	N.S	1.357	"	"	N.S	7.363	"	"	N.S	1.791	"	"	N.S

(b) Leaf Area

O - M	4.719	9.5	161.5	N.S	1.347	9.5	161.5	N.S	1.818	9.5	161.5	N.S	1.125	9.5	2.1	N.S
O - S	2.063	"	"	N.S	1.769	"	"	N.S	2.00	"	"	N.S	1.726	"	"	N.S
O - Su	6.000	"	"	N.S	1.150	"	"	N.S	3.600	"	"	N.S	1.145	"	"	N.S
M - S	2.285	"	"	N.S	2.286	"	"	N.S	1.100	"	""	N.S	1.542	""	"	N.S
M - Su	1.273	"	"	N.S	1.550	"	"	N.S	1.176	"	"	N.S	1.286	"	"	N.S
S - Su	2.909	"	"	N.S	1.538	"	"	N.S	7.400	"	"	N.S	1.319	"	"	N.S

F = Variance Ratio
P = Probability Value
R = Result of test
* = Significance at 5% level
** = Significance at 20% level
N.S = No significance either at 5% or 20% level

TABLE 61c

Plant Growth Curves

Four plants growing on Stockless soil with 5 cwt./N.P.K.

(a) Dry Weight

Plant Type \ Regression Equation	Linear				Quadratic				Cubic				Total			
	F	P		R	F	P		R	F	P		R	F	P		R
		20%	5%			20%	5%			20%	5%			20%	5%	
O - M	1.200	9.5	161.5	N.S	2.619	9.5	161.5	N.S	1.185	9.5	161.5	N.S	1.362	2.1	4.3	N.S
O - S	4.500	"	"	N.S	4.048	"	"	N.S	1.519	"	"	N.S	1.416	"	"	N.S
O - Su	1.125	"	"	N.S	1.954	"	"	N.S	2.000	"	"	N.S	1.221	"	"	N.S
M - S	5.400	"	"	N.S	1.545	"	"	N.S	1.28	"	"	N.S	1.929	"	"	N.S
M - Su	1.067	"	"	N.S	1.341	"	"	N.S	1.688	"	"	N.S	1.664	"	"	N.S
S - Su	5.062	"	"	N.S	2.073	"	"	N.S	1.317	"	"	N.S	1.160	"	"	N.S

(b) Leaf Area

Plant Type	Linear F	P 20%	P 5%	R	Quadratic F	P 20%	P 5%	R	Cubic F	P 20%	P 5%	R	Total F	P 20%	P 5%	R
O - M	3.538	9.5	161.5	N.S	1.059	9.5	161.5	N.S	1.666	9.5	161.5	N.S	1.348	2.1	4.3	N.S
O - S	1.071	"	"	N.S	1.307	"	"	N.S	2.364	"	"	N.S	1.836	"	"	N.S
O - Su	6.231	"	"	N.S	1.353	"	"	N.S	1.440	"	"	N.S	1.563	"	"	N.S
M - S	3.285	"	"	N.S	1.385	"	"	N.S	5.455	"	"	N.S	2.475	"	"	**
M - Su	1.761	"	"	N.S	2.400	"	"	N.S	2.400	"	"	N.S	1.159	"	"	N.S
S - Su	5.786	"	"	N.S	2.091	"	"	N.S	2.273	"	"	N.S	2.868	"	"	**

F = Variance Ratio
P = Probability Value
R = Result of test
* = Significance at 5% level
** = Significance at 20% level
N.S = No significance either at 5% or 20% level

TABLE 64

Crop Geochemistry

Concentration of the geochemicals of the different plant types grown on different soil treatments throughout the Season

TOTAL ORGANIC NITROGEN

Date (Weeks)	Organic field				Stockless without N.P.K.				Stockless with 3 cwt. N.P.K.				Stockless with 5 cwt. N.P.K.			
	O	M	S	Su	O	M	S	Su	O	M	S	Su	O	M	S	Su
3	0.025	0.029	0.033	0.030	0.034	0.035	0.031	0.040	0.021	0.020	0.019	0.030	0.030	0.025	0.031	0.030
5	0.070	0.055	0.087	0.070	0.147	0.128	0.111	0.090	0.234	0.084	0.136	0.120	0.084	0.143	0.107	0.100
7	0.694	0.278	0.832	0.600	1.676	1.687	1.840	1.900	1.690	1.585	1.008	2.100	1.550	3.050	2.230	1.200
10	2.930	4.690*	3.295	2.800	2.296	1.780	2.510*	4.400	1.903	2.002	2.976	2.400	1.626	3.775	1.800	4.100*
12	4.936	4.020	6.440	10.200*	3.430*	3.030	2.280	4.700*	2.376	3.608	2.940	4.200*	2.170	3.840	1.820	3.200
14	5.560*	3.520	7.402*	3.600	1.900	3.290*	1.730	4.400	3.940*	2.940	5.250*	4.000	3.310	4.280	2.650*	3.200
17	4.590	3.530	1.900	2.000	1.770	2.830	1.900	5.000	3.300	3.980*	3.696	2.800	6.100*	7.200*	0.650	3.600
Mean ±	2.686	2.303	2.854	2.757	1.607	1.825	1.486	2.932	1.923	2.031	2.289	2.235	2.124	3.187	1.326	2.204
S.E	0.910	0.784	1.135	1.342	0.449	0.504	0.378	0.832	0.548	0.523	0.740	0.629	0.790	0.941	0.397	0.647
St. Dev.	2.412	2.079	3.010	3.558	1.192	1.336	1.003	2.207	1.454	1.386	1.961	1.667	2.095	2.495	1.054	1.716

NITRATES

Date (Weeks)	Organic field O	Organic field M	Organic field S	Organic field Su	Stockless without N.P.K. O	M	S	Su	Stockless with 3 cwt. N.P.K. O	M	S	Su	Stockless with 5 cwt. N.P.K. O	M	S	Su
3	0.075	0.061	0.085	0.090	0.076	0.083	0.079	0.050	0.084	0.082	0.088	0.090	0.082	0.090	0.073	0.050
5	0.229	0.141	0.181	0.160	0.158	0.271	0.199	0.140	0.265	0.168	0.176	0.200	0.162	0.221	0.221	0.290
7	2.382	1.195	1.459	0.830	2.487	2.525	2.301	2.000	1.752	2.051	0.240	2.980	2.084	3.517	3.108	2.400
10	5.064	4.966	6.786	5.100	5.244	4.537	4.037	3.700	4.124	5.106	4.856	3.300	2.703	6.159	5.249	7.300*
12	7.454	6.678	9.458	18.300*	5.795*	6.293	6.468*	8.400*	5.380	11.886*	9.604*	7.900*	3.367	7.880*	5.740*	4.900
14	11.445*	7.244*	12.296*	6.600	5.293	7.816*	2.738	8.000	6.270*	3.800	8.300	5.300	6.828*	2.600	2.517	2.700
17	2.347	1.916	0.942	0.960	2.121	1.643	1.153	2.400	1.980	3.350	1.660	1.300	5.400	1.890	0.300	1.990
Mean ±	4.142	3.171	4.456	4.577	3.024	3.309	2.425	3.527	2.835	3.777	3.560	3.010	2.947	3.193	2.457	2.804
S.E	1.566	1.157	1.891	2.481	0.921	1.129	0.795	1.297	0.924	1.520	1.531	1.073	0.949	1.104	0.901	0.966
St. Dev.	4.150	3.067	5.012	6.575	2.441	2.993	2.108	3.438	2.451	4.028	4.058	2.845	2.516	2.926	2.390	2.561

All concentrations as mg/plant

(O, M, S) = Barley var. 'Rika'
Su = Barley var. 'Sultan'
S.E = Standard error
St. Dev. = Standard deviation
* = Maximum concentrations

TABLE 64A

<u>Crop Geochemistry</u>

Concentration of the geochemicals of the different plant types grown on different soil treatments throughout the Season

POTASSIUM

Date (Weeks)	Organic field				Stockless without N.P.K.				Stockless with 3 cwt. N.P.K.				Stockless with 5 cwt. N.P.K.			
	O	M	S	Su	O	M	S	Su	O	M	S	Su	O	M	S	Su
3	0.098	0.147	0.141	0.200	0.460	0.350	0.250	0.600	0.506	0.400	0.390	0.700	0.300	0.500	0.400	0.400
5	1.470	0.690	1.100	0.900	2.300	0.600	2.200	2.000	3.500	2.200	2.900	2.900	1.700	2.600	2.000	1.900
7	34.28	3.200	2.300	13.200	40.200*	39.500*	36.700*	33.00	30.400*	36.300*	17.310	42.00*	14.800	39.100	35.800*	1.106
10	39.435	44.120	36.100	23.400	38.700	16.200	21.000	51.000*	29.900	27.700	31.200	36.400	13.900	45.500*	29.100	53.300*
12	43.530	76.220*	64.200*	120.300*	33.020	18.400	18.900	34.300	22.000	32.700	18.200	38.300	16.200	31.500	27.200	23.500
14	65.00*	28.800	38.500	25.300	13.680	15.100	10.300	21.800	25.400	16.200	32.100*	30.600*	25.700	26.900	25.300	27.300
17	8.650	10.600	2.100	28.800	0.003	7.800	4.200	16.300	8.100	10.300	11.800	8.200	40.00*	5.500	1.800	11.700
Mean ±	27.495	23.397	20.634	30.300	18.338	14.021	13.221	22.714	17.157	17.971	16.271	22.729	16.971	21.657	17.371	17.029
S.E	9.289	10.758	9.667	15.588	6.963	2.650	4.975	6.889	4.798	5.484	4.696	6.807	3.489	7.007	5.771	7.308
St. Dev.	24.615	28.51	25.618	41.307	18.453	13.423	13.183	18.258	12.714	14.532	12.445	18.038	9.248	18.569	15.294	19.367

PHOSPHORUS

Date (Weeks)	O	M	S	Su	O	M	S	Su	O	M	S	Su	O	M	S	Su
3	0.006	0.005	0.007	0.010	0.021	0.019	0.012	0.002	0.021	0.020	0.016	0.020	0.023	0.032	0.019	0.020
5	0.020	0.010	0.011	0.010	0.004	0.007	0.080	0.050	0.076	0.056	0.080	0.070	0.032	0.090	0.066	0.040
7	0.120	0.140	0.190	0.030	1.150	0.320	1.080	0.240	0.580	0.560	0.350	1.200	0.830	1.410	0.480	0.060
10	0.440	0.520	0.330	0.299	0.700	1.040	0.390	2.800	2.850*	0.330	0.310	2.200*	1.350	2.780*	1.310	2.100*
12	0.520	0.640	2.150*	3.100*	0.660	2.650	2.130*	0.700	0.380	1.690*	0.330	0.600	0.330	1.920	1.680*	1.600
14	1.060	1.410*	1.110	0.800	1.390*	3.550*	1.386	3.900*	2.595	0.501	0.990	0.900	1.650*	2.500	0.430	0.500
17	1.400*	0.590	0.200	0.240	0.370	0.180	0.990	0.600	0.330	0.310	2.590*	0.306	0.670	1.360	0.110	0.400
Mean ±	1.938	0.474	0.571	0.641	0.613	1.109	0.867	1.185	0.974	0.496	0.667	0.756	0.698	1.442	0.584	0.674
S.E	1.442	0.186	0.299	0.422	0.200	0.539	0.288	0.579	0.455	0.213	0.341	0.290	0.238	0.406	0.247	0.316
St. Dev.	3.823	0.942	0.791	1.120	0.530	1.427	0.764	1.535	1.207	0.565	0.905	0.769	0.630	1.077	0.656	0.837

All concentrations as mg/plant

(O, M, S) = Barley var. 'Rika'
Su = Barley var. 'Sultan'
S.E = Standard error
St. Dev. = Standard deviation
* = Maximum concentrations

TABLE 64B

Crop Geochemistry

Concentration of the geochemicals of the different plant types grown on different soil treatments throughout the Season

CALCIUM

Date (weeks)	Organic field				Stockless without N.P.K.				Stockless with 3 cwt. N.P.K.				Stockless with 5 cwt. N.P.K.			
	O	M	S	Su	O	M	S	Su	O	M	S	Su	O	M	S	Su
3	0.027	0.019	0.023	0.034	0.038	0.007	0.022	0.042	0.083	0.076	0.052	0.105	0.078	0.091	0.071	0.170
5	0.489	0.439	0.498	0.284	0.056	0.115	0.777	0.703	0.137	0.707	1.032	0.842	0.532	0.294	0.672	1.008
7	4.667	1.066	2.456	2.014	6.277	9.439	1.367	10.953*	5.729	9.029	4.619	12.094*	6.975	7.356	9.826	3.945
10	7.810	7.761	4.797	8.751	6.419*	5.234	4.623*	9.786	5.583	6.102*	5.177	10.845	3.739	7.967*	14.711*	2.126
12	3.734	7.245	3.589	13.893*	2.939	3.708	0.191	5.671	2.328	3.693	2.637	4.636	3.118	3.152	2.898	3.086
14	14.211*	12.149*	11.706*	9.452	4.377	6.521	3.303	6.424	5.775	5.229	7.518*	8.061	5.809	5.281	7.943	6.469*
17	0.833	1.134	0.923	1.487	3.785	10.745*	0.179	3.449	7.878*	1.336	0.503	4.814	9.311*	6.018	0.354	2.888
Mean ±	4.539	4.259	3.436	5.131	3.413	5.109	1.494	5.290	3.930	3.739	3.077	5.926	4.235	4.308	5.224	2.813
S.E	1.921	1.796	1.532	2.073	0.989	1.582	0.675	1.584	1.160	1.234	1.053	1.751	1.273	1.211	2.147	0.777
St. Dev.	5.089	4.760	4.060	5.493	2.620	4.192	1.789	4.197	3.074	3.270	2.789	4.641	3.373	3.209	5.689	2.060

MAGNESIUM

Date (weeks)	O	M	S	Su	O	M	S	Su	O	M	S	Su	O	M	S	Su
3	0.019	0.030	0.014	0.035	0.046	0.047	0.029	0.054	0.050	0.046	0.039	0.053	0.044	0.049	0.042	0.046
5	0.076	0.057	0.066	0.062	0.091	0.021	0.100	0.079	0.124	0.092	0.101	0.099	0.071	0.016	0.073	0.080
7	0.693	0.061	0.327	0.279	0.930	1.063	0.858*	0.865	0.618	0.763	0.349	1.075	0.657	0.900	1.042	0.527
10	1.426	0.177	1.142	1.386	1.268	0.784	0.684	2.871*	0.822	1.179	1.383	0.926	0.449	1.029	0.558	1.047
12	3.629*	2.277*	1.848	4.541*	1.303*	1.057	0.414	1.375	0.567	1.142	0.474	1.381	0.443	5.985*	0.683	0.676
14	2.342	2.168	3.305*	1.594	1.105	1.407*	0.719	1.717	2.076*	1.293	2.558*	1.881*	1.546	1.623	1.323*	1.719
17	1.233	1.412	0.704	0.958	1.060	0.613	0.772	1.854	1.277	1.785*	1.577	1.262	2.230*	1.513	0.254	1.892*
Mean ±	1.345	0.863	1.058	1.265	0.825	0.713	0.511	1.259	0.791	0.900	0.926	0.954	0.777	1.588	0.568	0.855
S.E	0.488	0.391	0.447	0.594	0.200	0.199	0.126	0.380	0.265	0.224	0.355	0.253	0.307	0.770	0.184	0.278
St. Dev.	1.293	1.037	1.184	1.575	0.530	0.526	0.333	1.029	0.703	0.594	0.940	0.670	0.814	2.040	0.488	0.737

All concentrations as mg/plant

(O, M, S) = Barley var. 'Rika'
Su = Barley var. 'Sultan'
S.E = Standard error
St. Dev. = Standard deviation
* = Maximum concentrations

TABLE 64$_c$

Crop Geochemistry

Concentration of the geochemicals of the different plant types grown on different soil treatments, throughout the season

SODIUM

Date (weeks)	Organic Field				Stockless without N.P.K.				Stockless with 3 cwt. N.P.K.				Stockless with 5 cwt. N.P.K.			
	O	M	S	Su	O	M	S	Su	O	M	S	Su	O	M	S	Su
3	0.100	0.123	0.099	0.029	0.081	0.088	0.062	0.082	0.088	0.093	0.059	0.068	0.059	0.108	0.059	0.067
5	0.275	0.287	0.231	0.251	0.167	0.060	0.158	0.149	0.241	0.161	0.135	0.122	0.107	0.051	0.118	0.138
7	1.729	0.334	0.696	0.538	3.184	2.732	2.424*	2.523	1.932	2.042	1.205	2.887	1.780	3.505	2.901	1.146
10	8.266*	7.800*	9.786*	4.970	3.427*	1.321	0.515	10.39*	2.880	4.320	2.880	2.240	1.441	3.378	1.432	3.420
12	3.455	2.493	4.404	14.073*	2.501	3.485*	0.365	3.919	1.504	2.814	3.060	4.00*	1.474	7.400	1.540	2.010
14	3.584	2.180	6.624	4.048	2.753	2.759	1.432	1.489	4.350*	4.740*	3.410*	3.536	3.150	7.568*	4.006*	3.680*
17	2.985	2.832	1.247	1.428	2.110	3.073	1.351	3.929	1.870	4.740	2.800	1.876	5.400*	2.926	0.557	2.800
Mean ±	2.913	2.293	2.610	3.618	2.032	1.931	0.901	2.884	1.871	3.373	1.936	2.104	1.916	3.562	1.515	1.907
S.E	1.04	1.013	1.003	1.812	0.518	0.541	0.327	1.403	0.541	0.657	0.542	0.585	0.703	1.147	0.558	0.363
St. Dev.	2.76	2.685	2.658	4.803	1.373	1.436	0.866	3.717	1.433	1.741	1.436	1.549	1.863	3.041	1.477	1.492

All concentrations as mg/plant

(O, M, S) = Barley var. 'Rika'
(Su) = Barley var. 'Sultan'
S.E = Standard error
St. Dev. = Standard deviation
* = Maximum concentrations

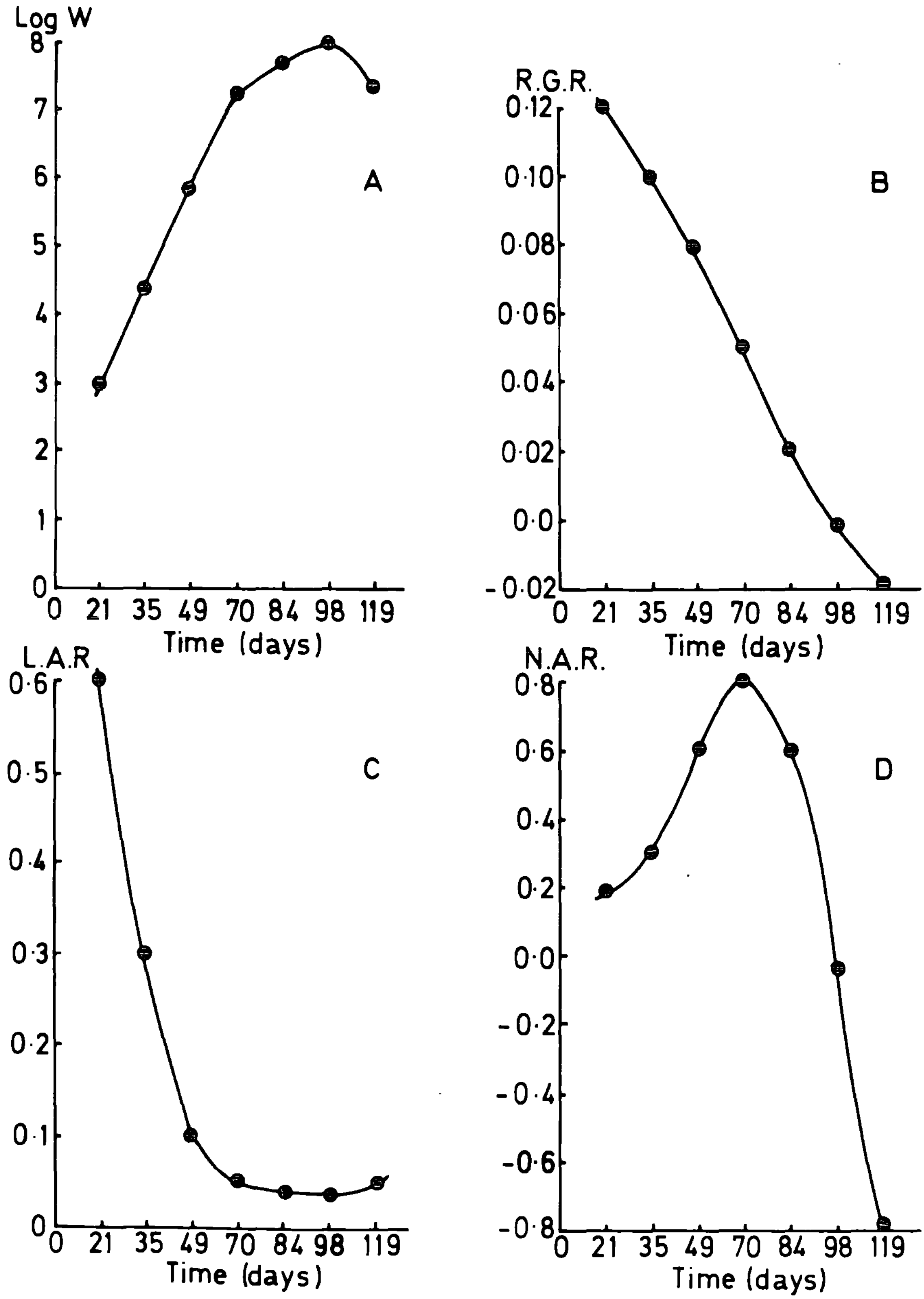


FIG.**44**, Progress Curves of (A) Log Dry Weight. (B) R.G.R Reltive Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. O Barley grown on Organic field. (Lower Wassecks)

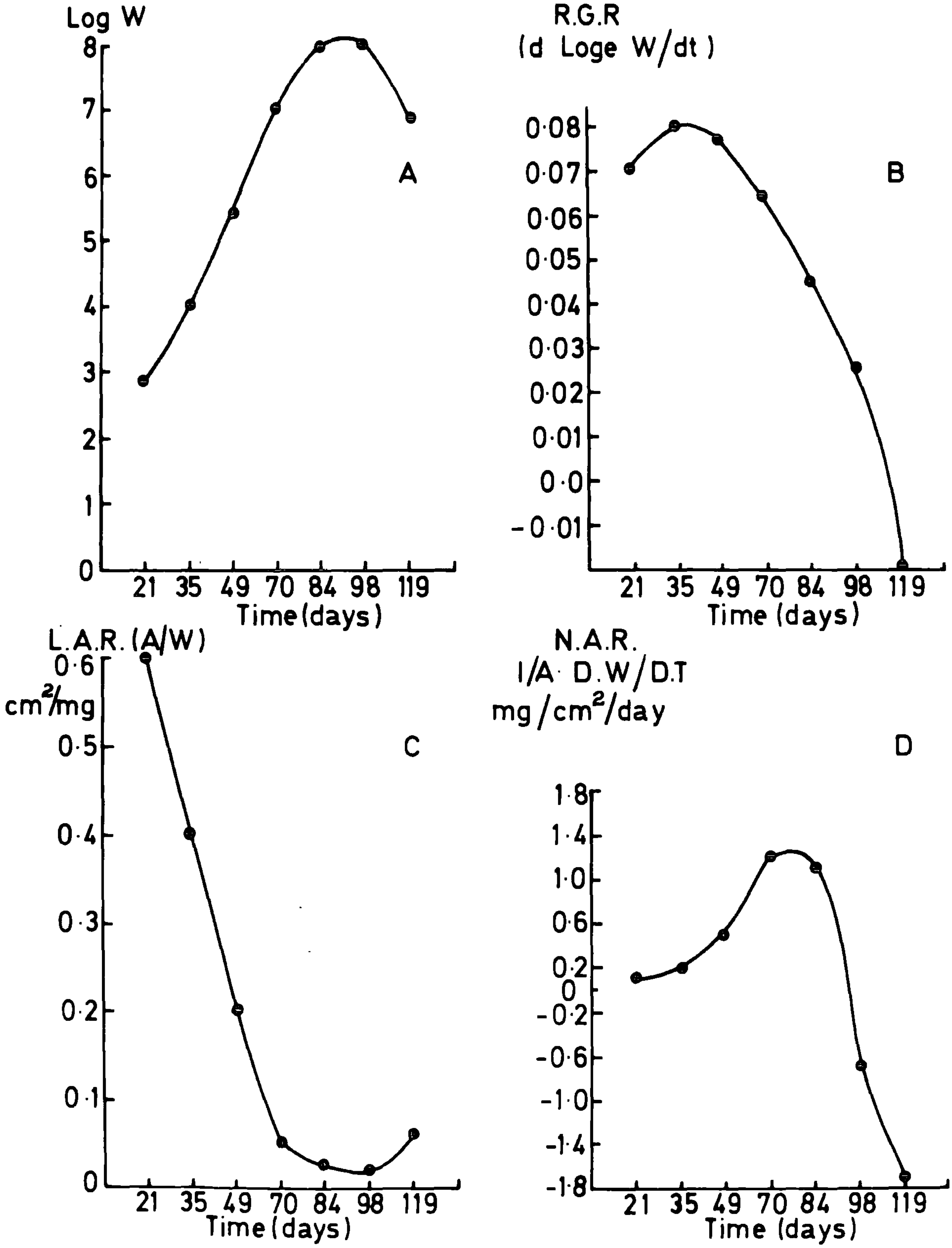


FIG.44₂ Progress Curves of (A) Log Dry Weight (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. S Barley grown on organic field (Lower Wassicks)

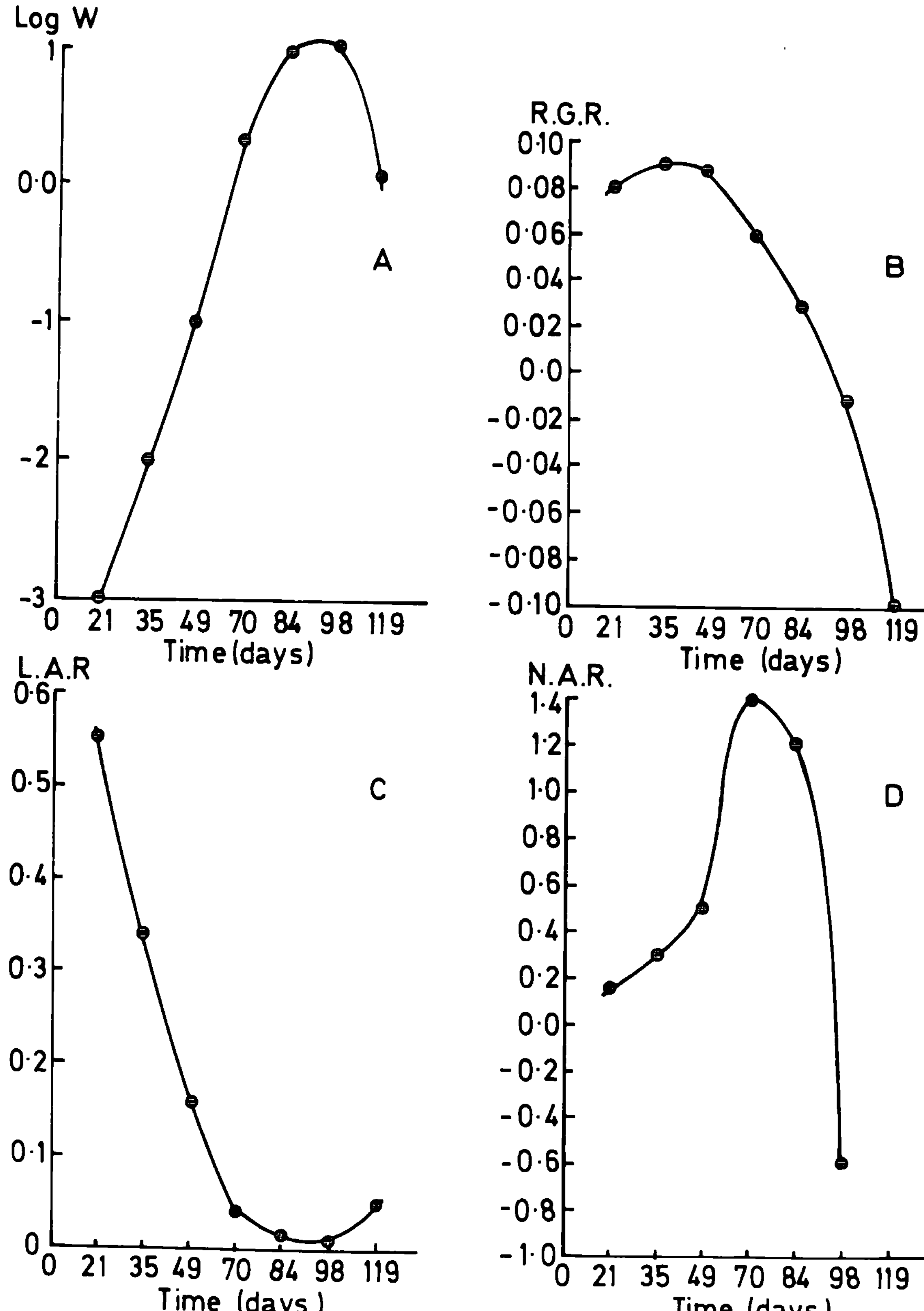


FIG.44₃ Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. Barley (Sultan) grown on Organic field. (Lower Wassicks)

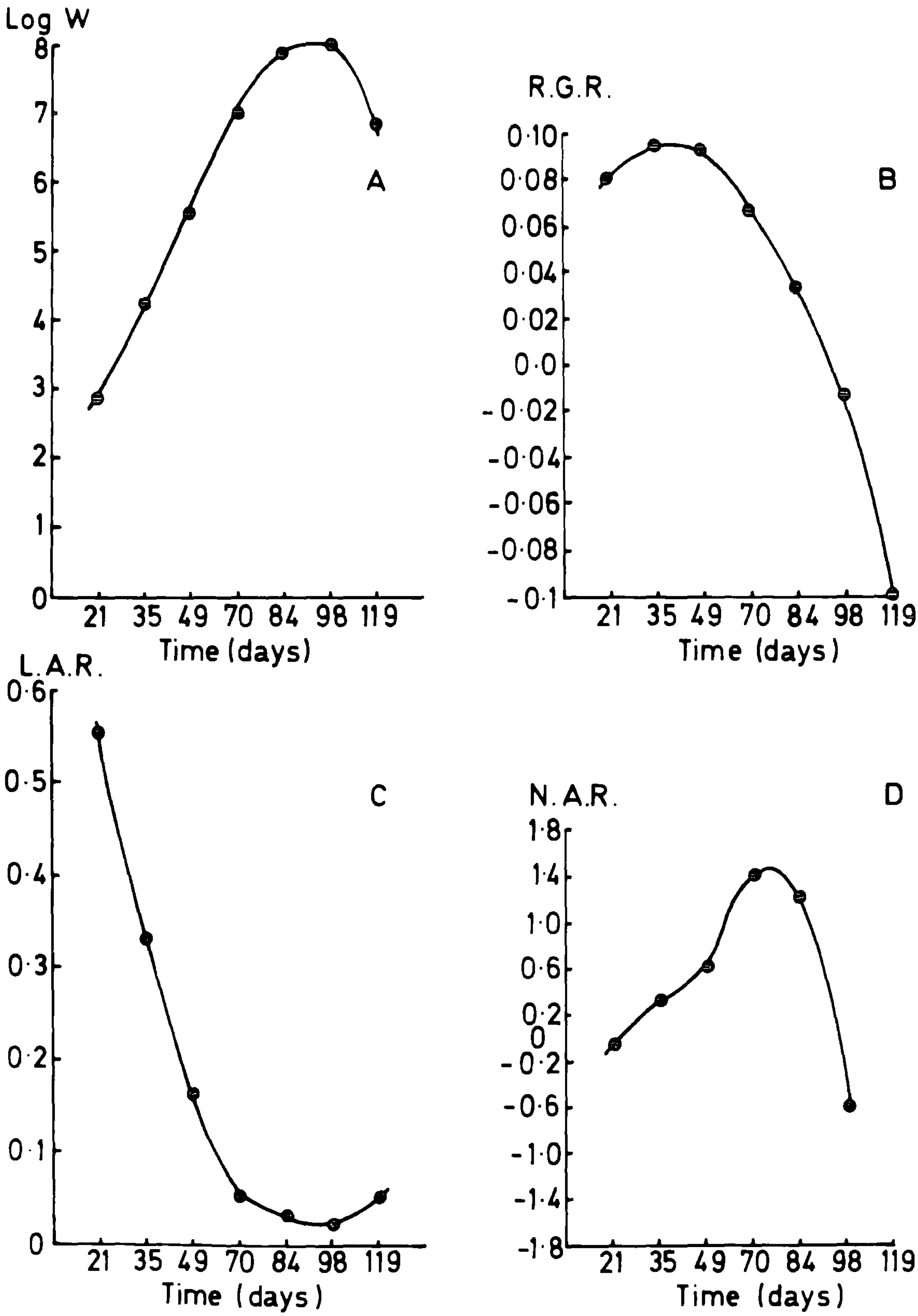


FIG.44₄ Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. O Barley grown on stockless field. (Road Field)

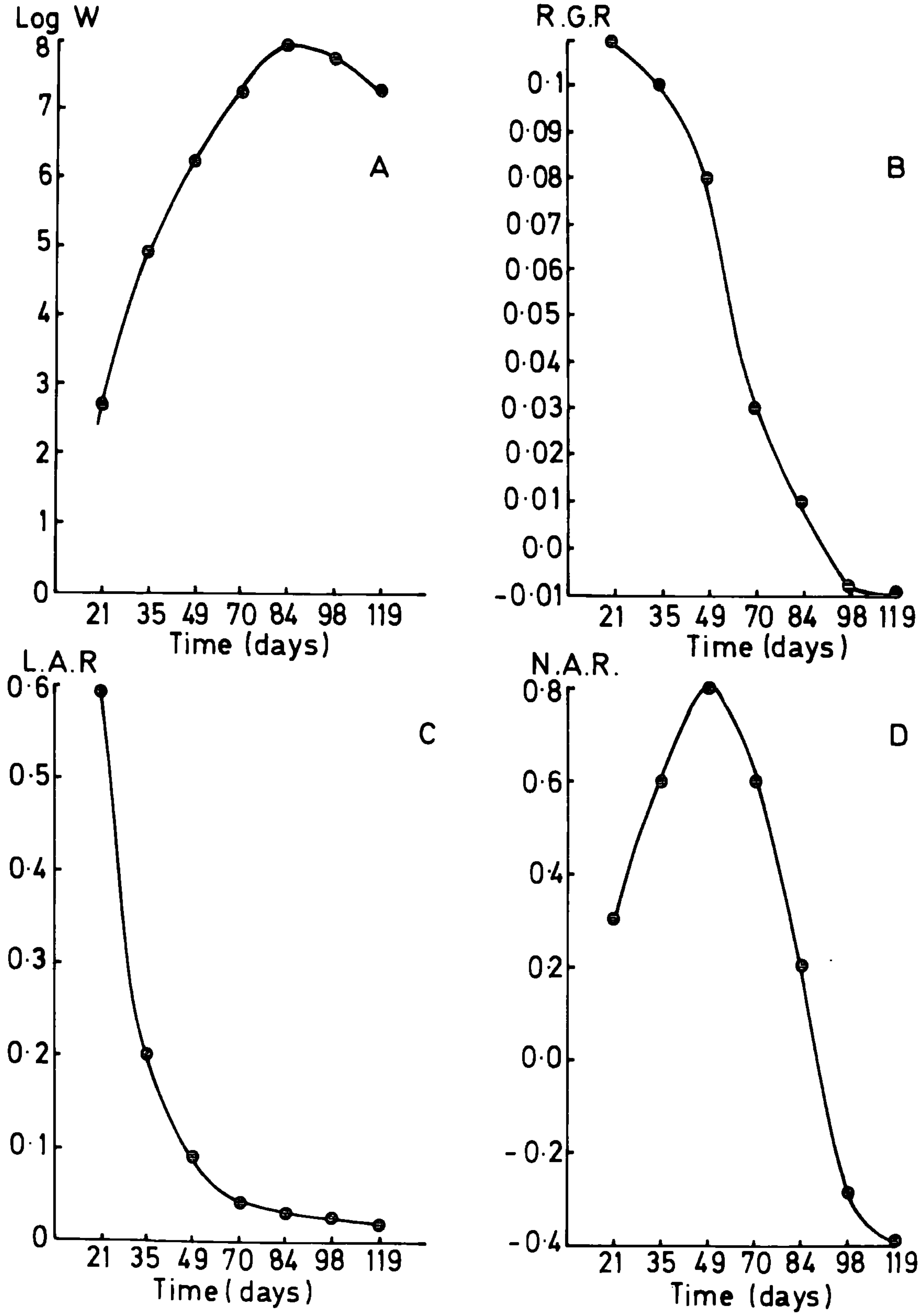


FIG.**44**5 Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. M Barley grown on stockless field. (Road Field)

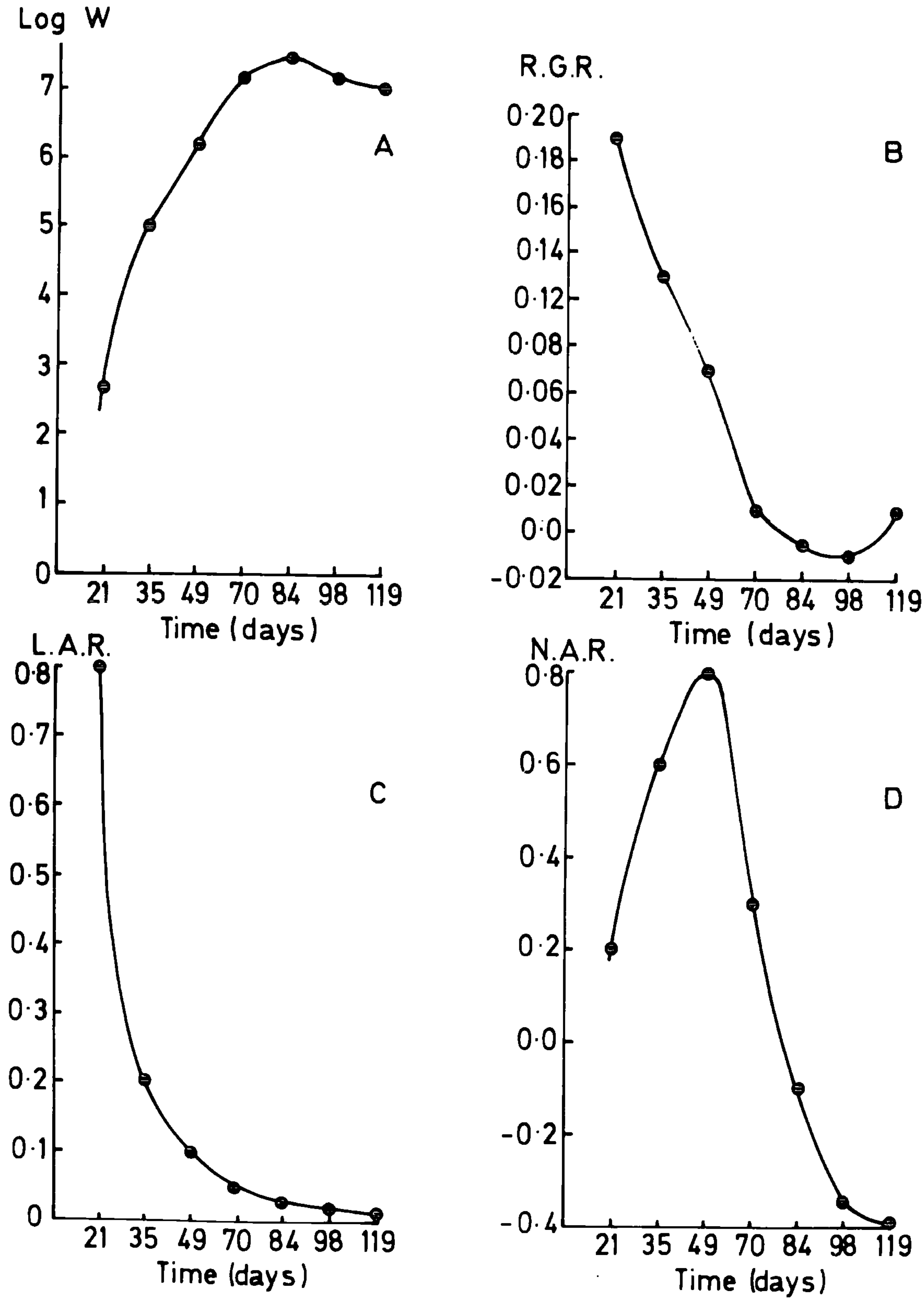


FIG.**44**6 Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. S Barley grown on stockless field. (Road Field.)

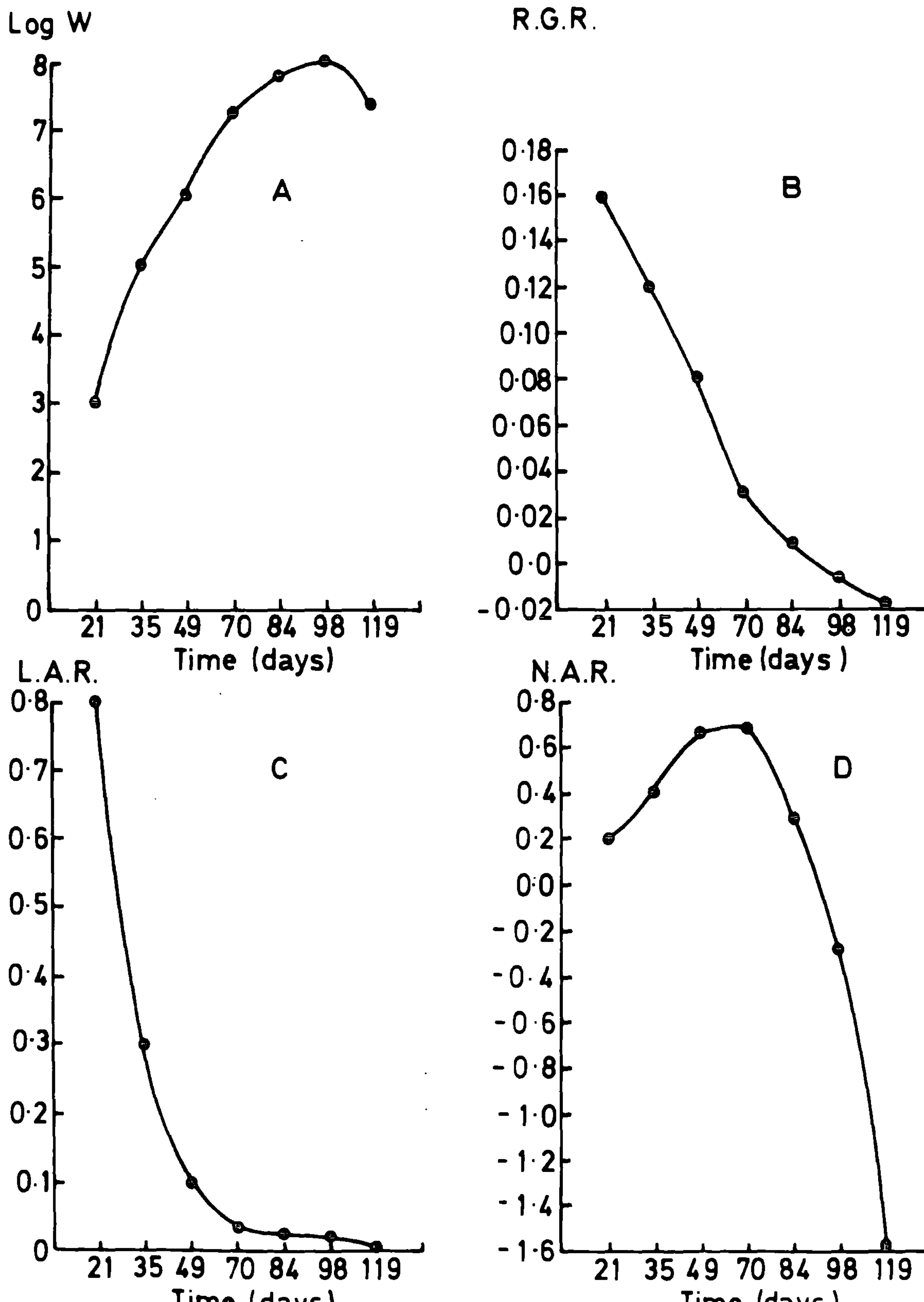


FIG. 44, Progress Curves of (A) Log Dry Weight (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimulation Rate. O Barley grown on stockless field treated with 3cwt./acre N.P.K.

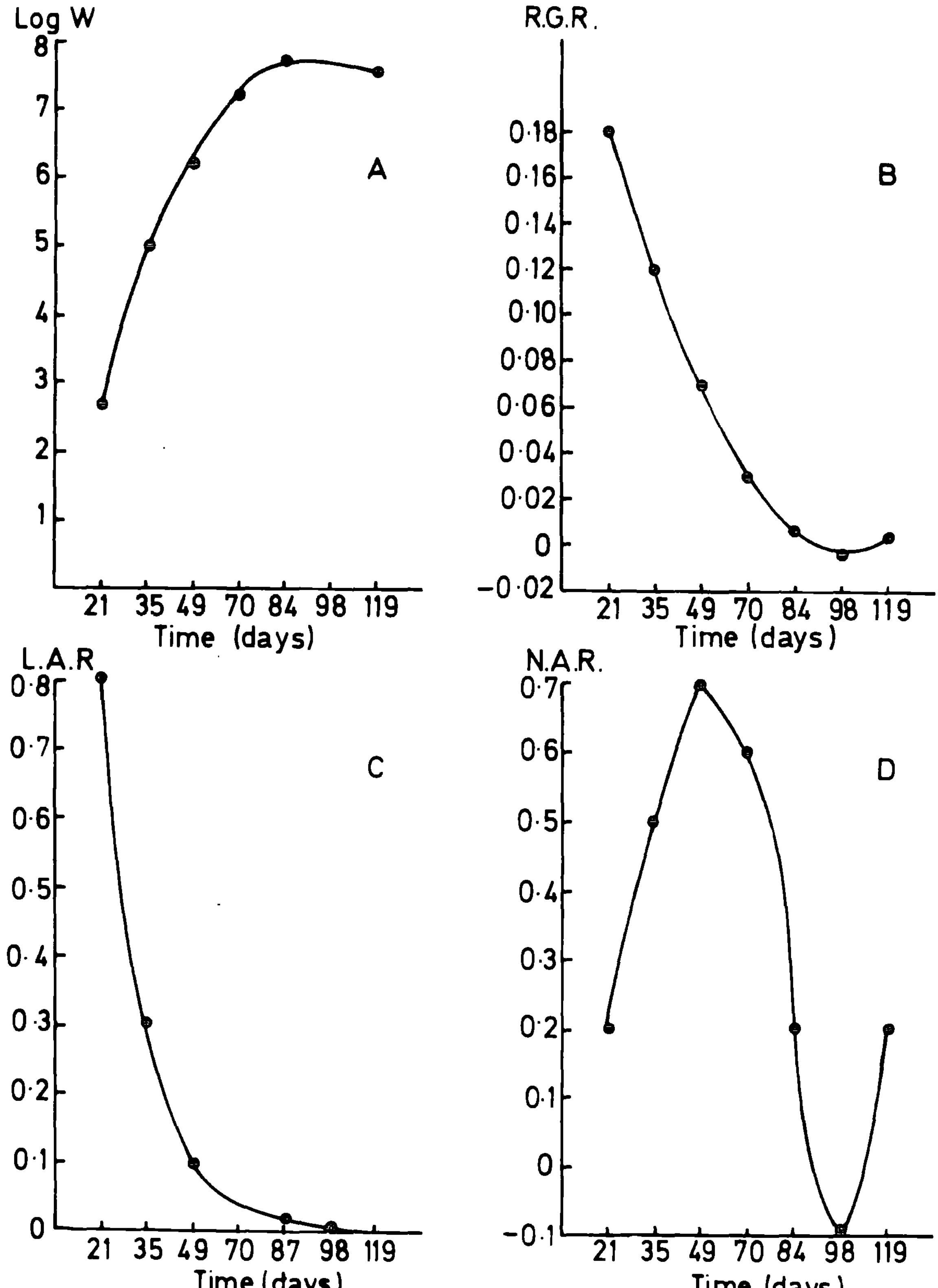


FIG.44B Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. M Barley grown on stockless field treated with 3 cwt/acre N.P.K.

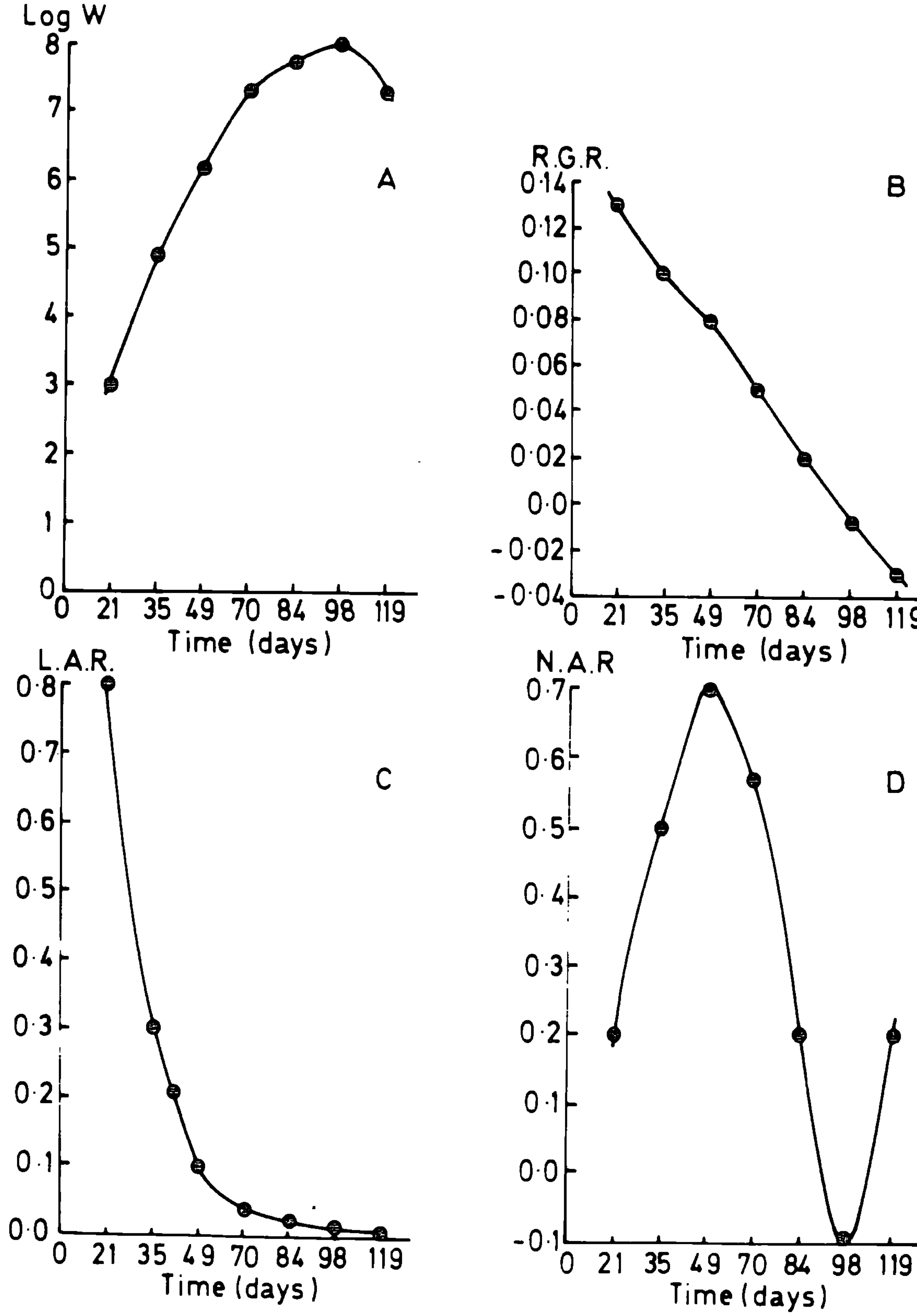


FIG. 44. Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. S Barley grown on Stockless soil treated with 3cwt/acre N.P.K.

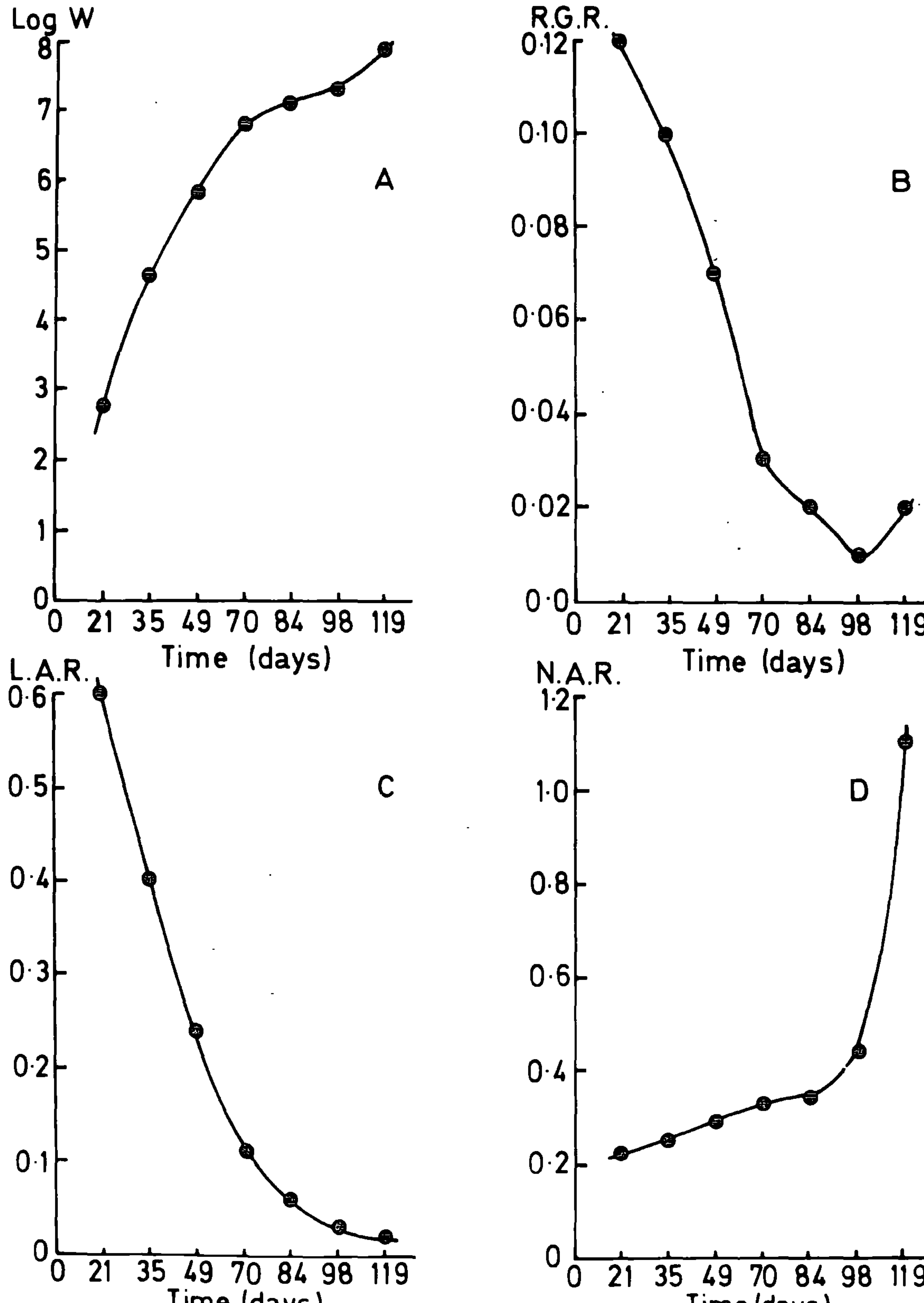


FIG. 44₁₀ Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Rate. (D) N.A.R. Net Assimilation Rate. O Barley grown on Stockless soil treated with 5cwt/acre N.P.K.

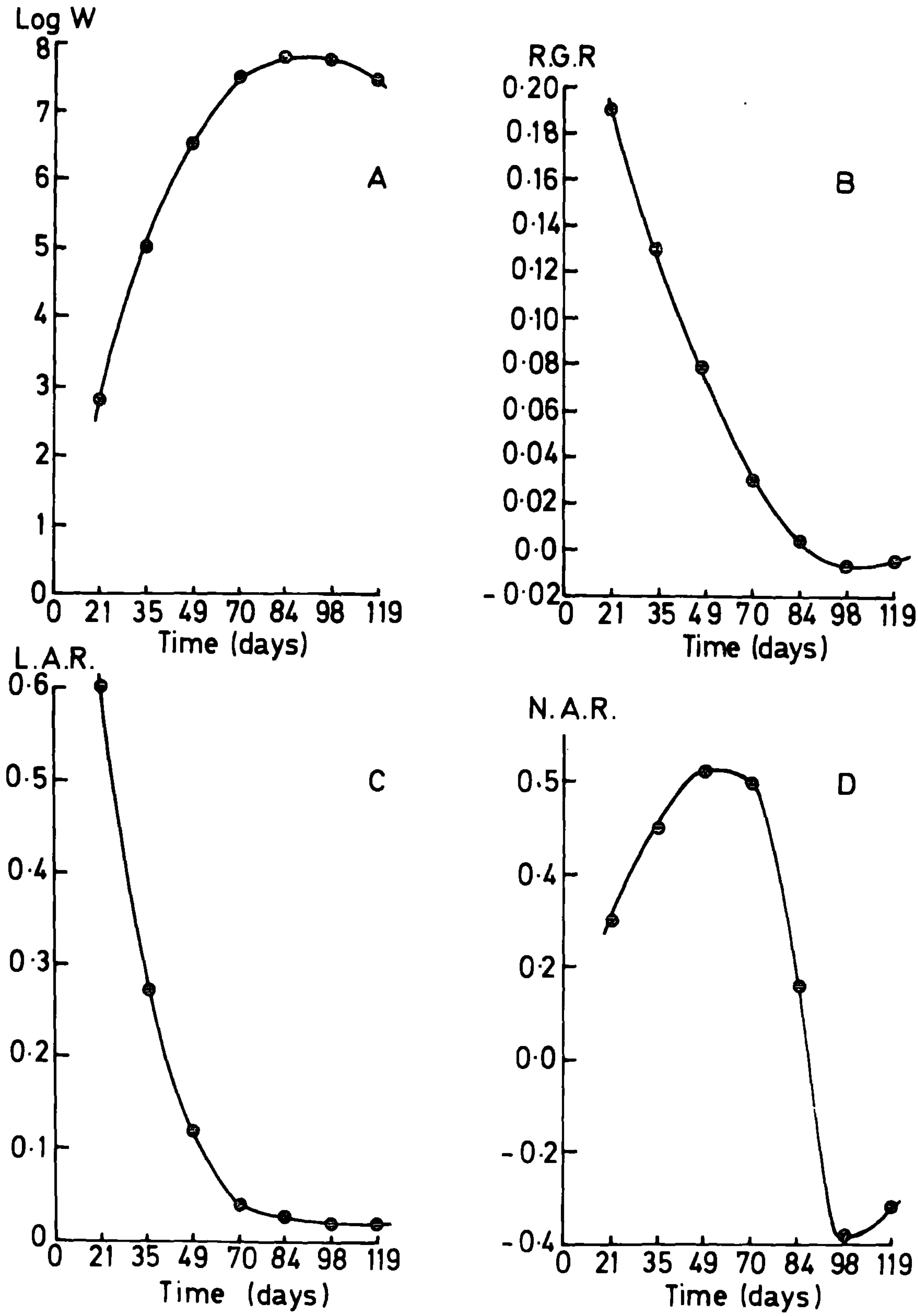


FIG.44ıı Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. 'M' Barley grown on Stockless soil treated with 5cwt./acre N.P.K.

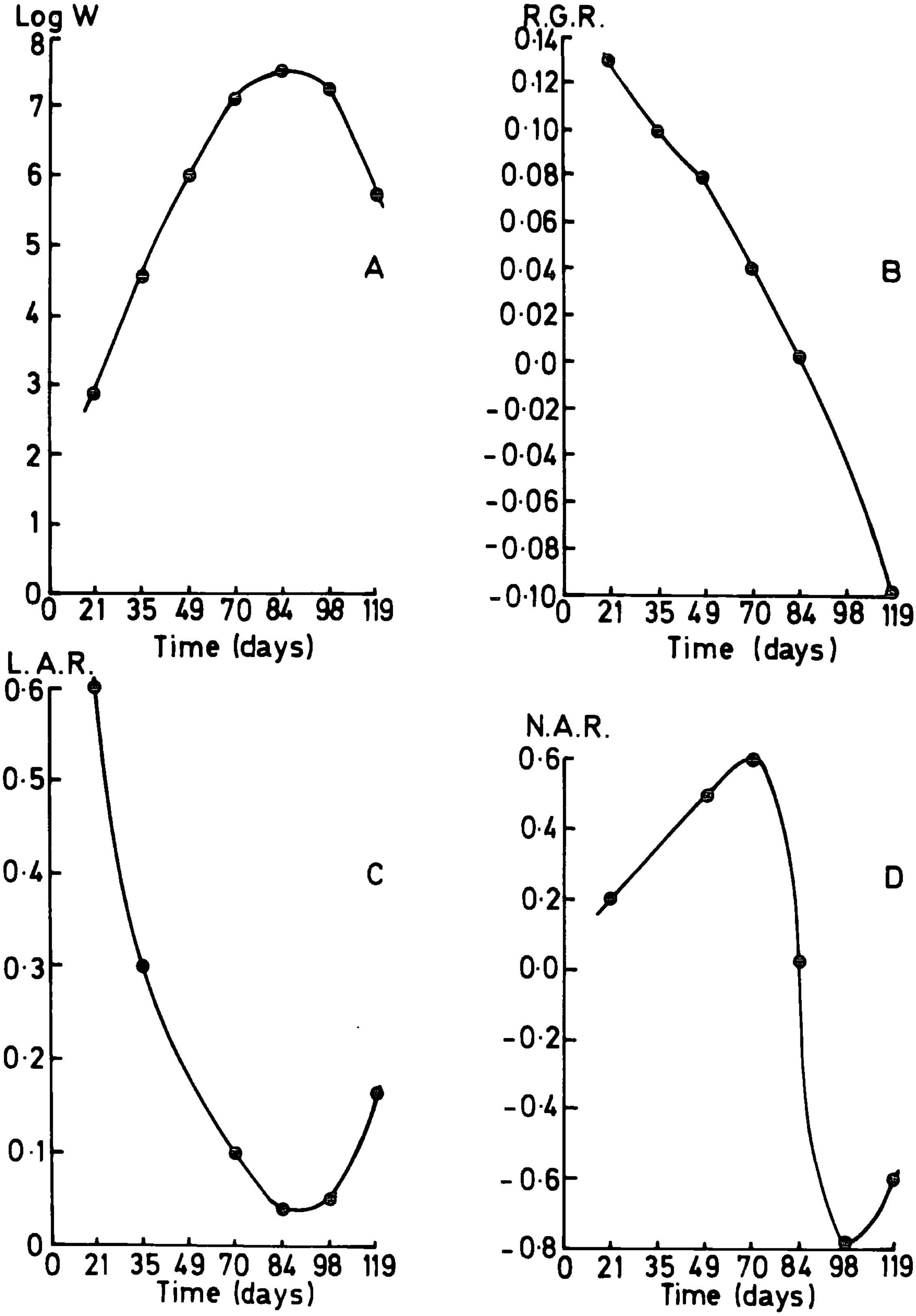


FIG.44.12 Progress Curves of (A) Log Dry Weight. (B) R.G.R. Relative Growth Rate. (C) L.A.R. Leaf Area Ratio. (D) N.A.R. Net Assimilation Rate. S Barley grown on Stockless soil treated with 5cwt./acre N.P.K.

SECTION VI.

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O

M

S

PLATE 1

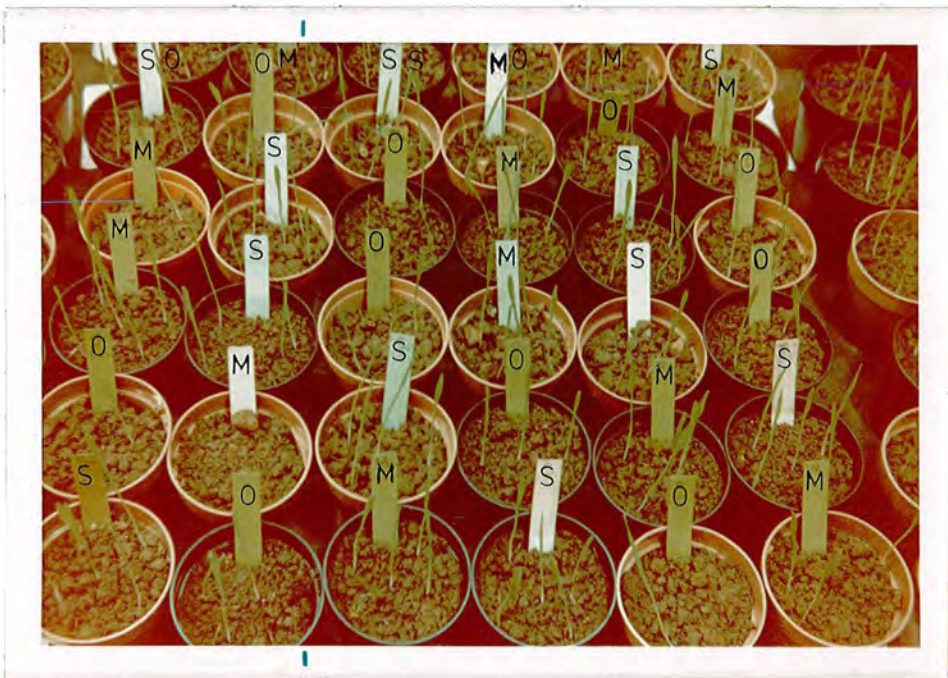

PLATE 2. Latin square arrangements in the greenhouse (growth cabinet) using three types of Barley seeds (O, M and S) growing on Organic and Stockless soils.

-O-

-S-

PLATE 3.

O = Organic Field

S = Stockless Field

PLATE 4. Lysimeter construction

(A) Deep lysimeters.

PLATE 5