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OBSERVATIONS ON TOPDRESSING A COPPER-DEFICIENT PASTURE IN SOUTH-EASTERN QUEENSLAND

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SUMMARY.

Trials were conducted in successive years to examine the effect of topdressing with copper sulphate, alone and in combination with superphosphate and with superphosphate plus lime, on the botanical and chemical composition of pasture and on the growth rate of grazing Hereford heifers.

The pasture was predominantly narrow-leaved carpet grass with limited amounts of paspalum and white clover. Only where soil treatments included ground limestone at 1 ton per acre was there a marked change in botanical composition of this pasture, white clover increasing to 33 per cent. of ground cover. Paspalum and white clover maintained higher average copper levels than narrow-leaved carpet grass in all treatments, including the control paddock.

Topdressing with copper sulphate at 14 lb. per acre at 6-monthly intervals was necessary to maintain an adequate copper status in grazing cattle.

Grazing cattle in the region show a stationary or declining weight during the winter months and increasing weight during summer and early autumn. There were no significant differences in weight between the experimental groups with respect to either summer-autumn gains or winter losses, indicating that copper deficiency is not the only factor limiting growth of cattle in this area.

All animals, including those from areas treated with superphosphate at 187 lb. per acre per annum, had an unsatisfactory blood inorganic phosphate during the winter months. This suggests that phosphate as well as copper may limit the growth rate of cattle on this property, and that heavier applications of superphosphate are required.

Parenteral copper therapy at 3-monthly intervals also maintained a satisfactory liver copper reserve in cattle grazing untreated pastures.

A pilot cobalt supplementation trial did not show a significant response in treated cattle but the supplemented group tended to make more satisfactory weight gains.

The cause of loss in weight in grazing cattle during winter and the syndrome of scouring and emaciation in certain wet winters when pasture appears adequate remain to be determined.

I. INTRODUCTION.

The property on which these observations were made is situated in south-eastern Queensland about 60 miles north of Brisbane and comprises about 3,000 acres. It carries approximately 1,000 head of mixed beef cattle, mainly bred on the property for sale as fatteners at about two years of age. The dominant pasture species is narrow-leaved carpet grass (*Axonopus affinis*). Paspalum (*Paspalum dilatatum*) and white clover (*Trifolium repens*) are present in limited quantities. A native sedge (*Carex appressa*) is abundant in some areas. Much of the land is subject to flooding and is badly drained.

Sutherland (1952) recorded the initial observations on this property. Serious losses occur in breeding cows and their calves and in yearlings, particularly in years when rainfall is high, the symptoms being marked scouring, emaciation and weakness. A diagnosis of copper deficiency was confirmed by the low levels of copper found in both blood and liver samples. Further confirmation of copper deficiency was obtained by a pilot trial, in which a clinical response occurred in animals receiving copper sulphate solution as a weekly drench.

II. 1951-53 TRIAL.

A field trial was initiated to study the effects of soil treatments on the pastures of the river frontage and on the animals grazing those pastures. Transect counts were used to assess changes in botanical composition, and variations in mineral composition of each pasture species were determined by chemical analyses. Hereford heifers were grazed on the treated pastures and their liveweights recorded.

(1) Methods.

Soil samples were taken with an iron auger, air-dried and prepared for analysis by grinding with pestle and mortar. Pasture samples were collected with stainless steel scissors, sorted into species by hand, then air-dried and milled in a laboratory mill containing no brass or copper parts.

Blood was drawn from the jugular vein, using stainless steel needles; the blood was collected in copper-free bottles containing potassium oxalate. Liver samples were taken by the liver biopsy technique of Loosmore and Allcroft (1951), using the instruments described by Dick (1944).

Copper in soil, pasture, blood and liver was determined by the method of Clare, Cunningham and Perrin (1945). The colorimetric procedure of Briggs (1922) was used in the analysis of phosphorus. The method of Dick and Bingley (1951) was used for the determination of molybdenum.

(2) Soil Type.

The soil of the area is a grey-brown loam of recent alluvial origin with poorly developed structure. Internal drainage is poor. It is acid in reaction

(pH 5·36) and has satisfactory potassium (replaceable K, m-equiv. per cent. = ·255) and nitrogen (0·19 per cent.) levels. Available phosphorus, however, is low, being 32 p.p.m. P_2O_5 in the top six inches. The total copper content ranges from 11 to 14 p.p.m.

(3) Experimental.

Twenty acres of this soil type on the river flats were surveyed into four paddocks, each of five acres. Soil treatments applied in March 1951 were kept to a minimum in order to reduce costs to a level commensurate with the form of land use adopted—breeding store cattle. The treatments were as follows:—

Paddock 1.—Copper sulphate 10 lb. per acre, ground limestone 1 ton per acre, superphosphate 187 lb. per acre.

Paddock 2.—Copper sulphate and superphosphate as for paddock 1.

Paddock 3.—Copper sulphate as for paddocks 1 and 2.

Paddock 4.—Untreated control.

Paddocks 1, 2 and 3 were renovated with tandem disc harrows and oversown in May 1951 with paspalum, red clover, white clover and lucerne. The red clover and lucerne did not become established.

Owing to drought and management difficulties it was not possible to complete the fencing and introduce experimental cattle to the paddocks until April 1952, 12 months after the initial topdressing. During this period, the rainfall was approximately 39 in., compared with the annual average of nearly 61 in. As more than half the actual rainfall was received in the three months immediately prior to the initial grazing, the wastage of lime and superphosphate through leaching would have been low.

Sixteen weaner Hereford heifers, divided into four groups of comparable age and weight, were maintained in the experimental paddocks from April 1952 to August 1953. All cattle were tuberculin tested and immunised against tetanus and blackleg at the commencement of the experiments. Cattle tick and worm burdens were kept at low levels by spraying with toxaphene and drenching with phenothiazine.

Soil samples were taken before the trial began. Routine examinations involved the collection monthly of pasture samples and quarterly of liver and blood samples. The experimental animals were weighed each month.

(4) Results.

The results are summarised in Table 1.

Pasture samples were taken from April 1952 to August 1953 following soil treatments in March 1951. Pasture from the topdressed paddocks showed a copper content slightly higher than that of the same species from the untreated area. The copper levels were higher in paspalum than in carpet grass. Molybdenum levels did not exceed 0·5 p.p.m. in either species.

Table 1.

COPPER CONCENTRATION AND BOTANICAL COMPOSITION OF PASTURE AND LIVER COPPER CONCENTRATION OF CATTLE—1951-53 TRIAL.

Paddock.	1.	2.	3.	4.
Pasture—				
Copper content (p.p.m. dry matter) (sampled monthly)—				
Carpet Grass Range	5–8	5–8	5–10	4–6
Carpet Grass Mean	6·3	6·9	6·5	5·1
Paspalum Range	7–12	7–12	7–12	5–10
Paspalum Mean	9·0	9·0	9·0	7·6
Botanical composition (percentage ground cover) in June, 1953—				
Carpet grass	88	93	98	96
Paspalum	3	5	2	1
Clover	9	2	0	3
Liver copper (p.p.m. dry matter)—				
April, 1952* Range	14–38	23–125	21–74	30–90
April, 1952* Mean	26	60	52	47
July, 1952	18	56	51	45
November, 1952	26	66	99	40
February, 1953	54	87	105	43
May, 1953	23	60	84	22
August, 1953 Range	15–18	16–190	27–90	14–42
August, 1953 Mean	16	68	54	28

* Immediately before being confined in the experimental paddocks.

In June 1953, line transects showed that carpet grass remained the predominant species in all paddocks, paspalum represented only 1–5 per cent. and significant amounts of clover occurred only in paddock 1, presumably due to the lime treatment.

Liver copper concentrations in the experimental animals were not high (14–125 p.p.m.) at the commencement of the trial. In paddock 1 they showed an increase only at the ninth month (February 1953) and then declined to below the pre-treatment level at the 15th month (August 1953). The heifers in paddocks 2 and 3 showed a similar pattern, with maximum levels at the ninth month, while those in paddock 4 gradually declined during the trial.

The liveweight changes are presented in Fig. 1. They show the usual pattern for grazing cattle in this region (Near North Coast)—stationary or declining liveweight during the winter months (April to August) and increasing liveweight during summer and early autumn. Weight gains of the group grazing the untreated pasture tended to be lower, but significant differences between groups could not be detected with such small numbers of cattle.

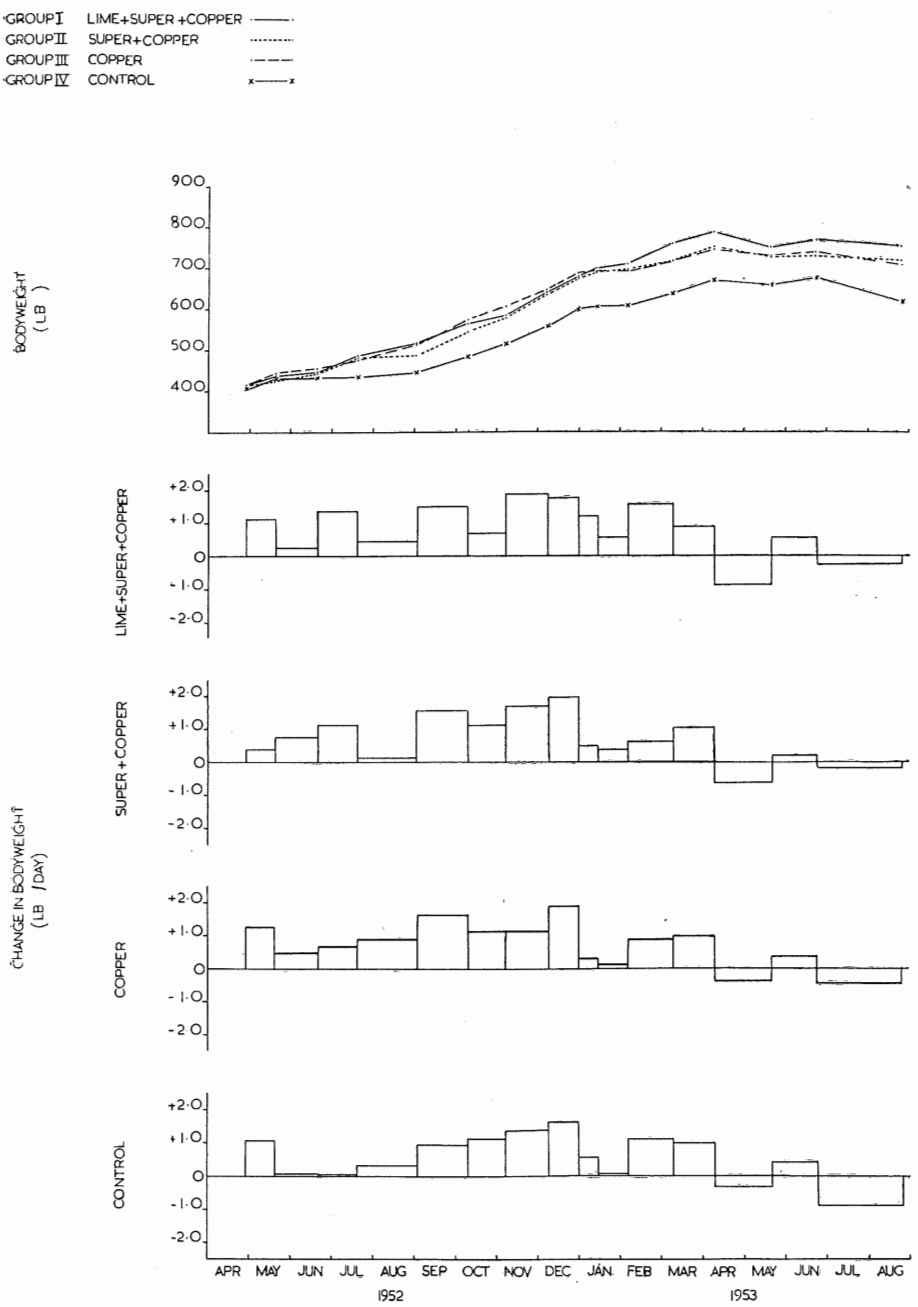

Fig. 1.

Mean Liveweight Changes in Hereford Heifers from Each Group During 1951-53 Trial.

Although all the experimental cattle lost weight during the winter months of 1953, they did not show the diarrhoea and weakness that had caused heavy losses in the winter of 1950. There were, however, no serious losses among the remainder of the cattle on this property during 1952 and 1953.

Rainfall each month during the experiment is shown in Table 2.

Table 2.

MONTHLY RAINFALL RECORDED AT DISTRICT OFFICIAL RECORDING STATION.

Month.	1950.	1951.	1952.	1953.	1954.
	in.	in.	in.	in.	in.
January	6·85	25·79	2·15	8·50	7·78
February	18·27	5·27	6·27	17·25	24·77
March	4·06	7·33*	11·55	8·25	6·03§
April	5·23	·38	3·57†	3·60	2·12
May	2·38	3·14	5·30	1·50	4·31
June	5·62	1·94	11·75	·20	2·68
July	9·47	·24	6·00	·43	12·60
August	3·91	·93	4·20	4·52	4·85
September	·42	·68	3·40	2·18‡	3·78‖
October	3·72	2·86	4·50	2·87	9·98
November	4·83	·23	·20	5·99	4·66
December	2·50	1·07	4·10	1·59	5·92
Totals—					
Apr.-Aug.	26·61	6·63	30·82	10·25	26·56
12 Months	67·26	49·86	62·99	56·88	89·48

* Soil treatments applied in March, 1951, for 1951–53 trial.

† Experimental heifers placed in paddocks for 1951–53 trial.

‡ End of 1951–53 trial on Sept. 2, 1953. Soil treatments applied on Sept. 5, 1953 for 1953–54 trial and experimental heifers placed in paddocks 1 week later.

§ Second soil treatments on Mar. 11, 1954, for 1953–54 trial and heifers removed from paddocks for seven days after topdressings.

‖ 1953–54 trial ended on Sept. 13, 1954.

(5) Conclusions.

Topdressing with copper sulphate at 10 lb. per acre, whether alone, with superphosphate or with superphosphate plus lime, applied 12 months prior to stocking, did not enable cattle grazing this predominantly carpet grass pasture to accumulate adequate liver copper reserves or to significantly improve their liveweight gains during 1952-53.

Both carpet grass and paspalum from the treated paddocks showed a slightly higher copper content than in the untreated area. Paspalum showed a higher copper concentration than carpet grass but represented only a small proportion of the pasture—less than 5 per cent. Only in the area treated with ground limestone was there an indication of change in botanical composition, white clover representing 9 per cent. of the pasture.

III. 1953-54 TRIAL.

(1) Experimental.

The 1953-54 trial was essentially a continuation of the previous trial, using the same four paddocks with certain modifications as follows:—

(1) Sixteen weaner heifers approximately six months old were selected from the 25 weaner heifers available on the property. The basis of selection was uniformity in age, type, weight and liver copper reserves. Seven of the remaining nine heifers were used for a copper therapy trial, described below.

(2) To control pasture growth during summer and early autumn, additional stock were added to each experimental paddock as required.

(3) Soil treatments were applied at intervals of approximately six months—on Sept. 5, 1953, and Mar. 11, 1954—to the same four paddocks, as follows:—

Paddock 1.—No further application of lime; superphosphate 187 lb. per acre plus copper sulphate 28 lb. per acre per annum. The superphosphate and copper sulphate were given in two applications of 93½ lb. and 14 lb. respectively.

Paddock 2.—As for paddock 1.

Paddock 3.—Two applications of copper sulphate as for paddocks 1 and 2.

Paddock 4.—No treatment.

(4) Monthly line transects were continued, as in the previous trial, to determine changes in botanical composition.

(5) The animals were placed in the experimental paddocks on Sept. 12, 1953, seven days after topdressing, sufficient rain having fallen to minimise the risk of copper toxicity from contamination of the pasture.

(2) Results.

(a) Pasture Copper.

The results of monthly pasture analyses and line transects are shown in Figs. 2 and 3.

Paddock 1.—Carpet grass absorbed copper quickly after topdressing. The copper concentration then fell sharply and three months after treatment had declined to a marginal to low level. Paspalum showed a less marked rise in copper and the subsequent fall was also less marked. Clover showed a similar pattern. Although carpet grass was dominant, the proportion of clover increased significantly in this paddock, due presumably to the initial application of ground limestone at 1 ton per acre in March 1951.

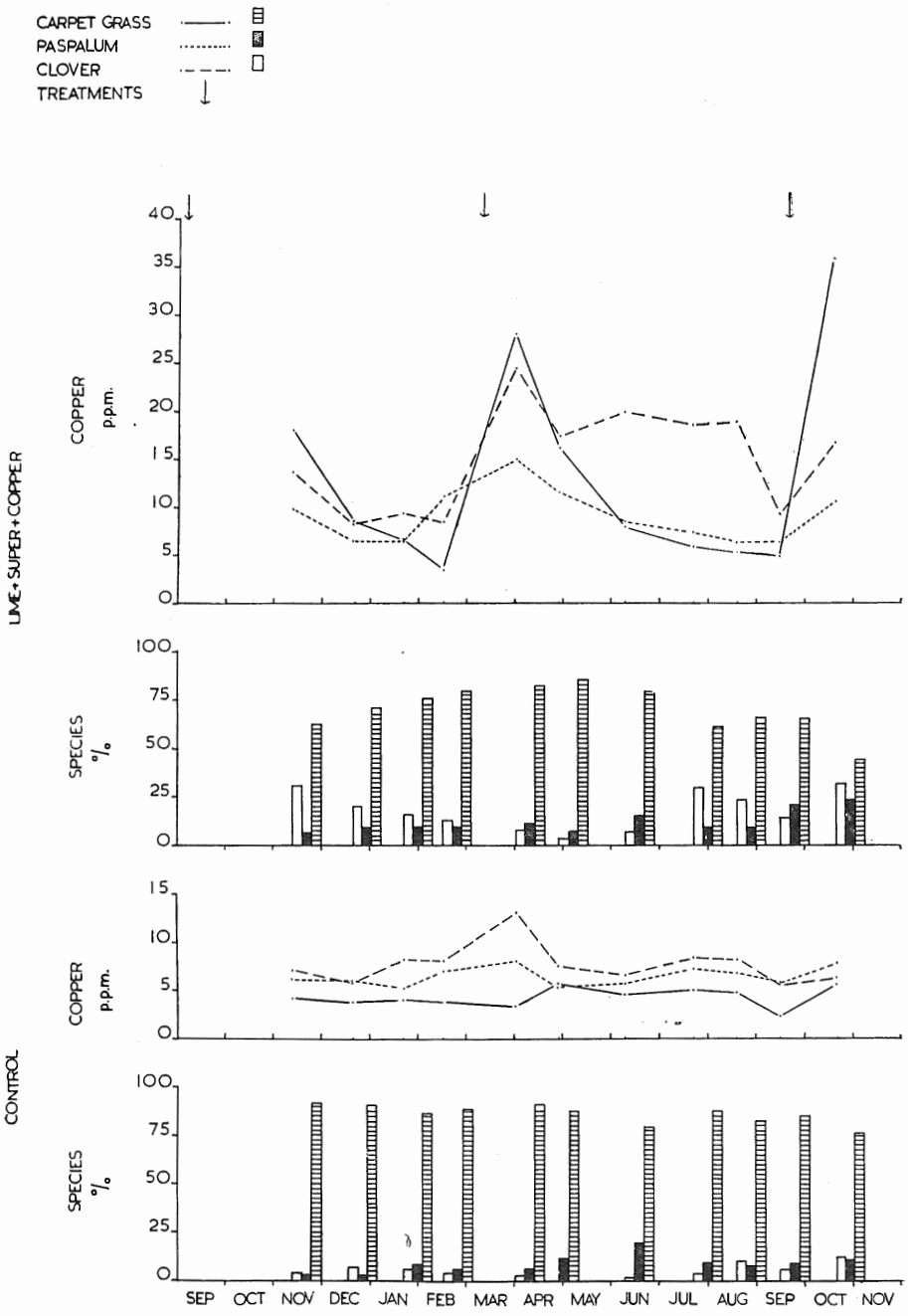

Fig. 2.

Copper Concentration and Botanical Composition of Pasture in Trial Paddocks 1 and 4 During 1953-54.

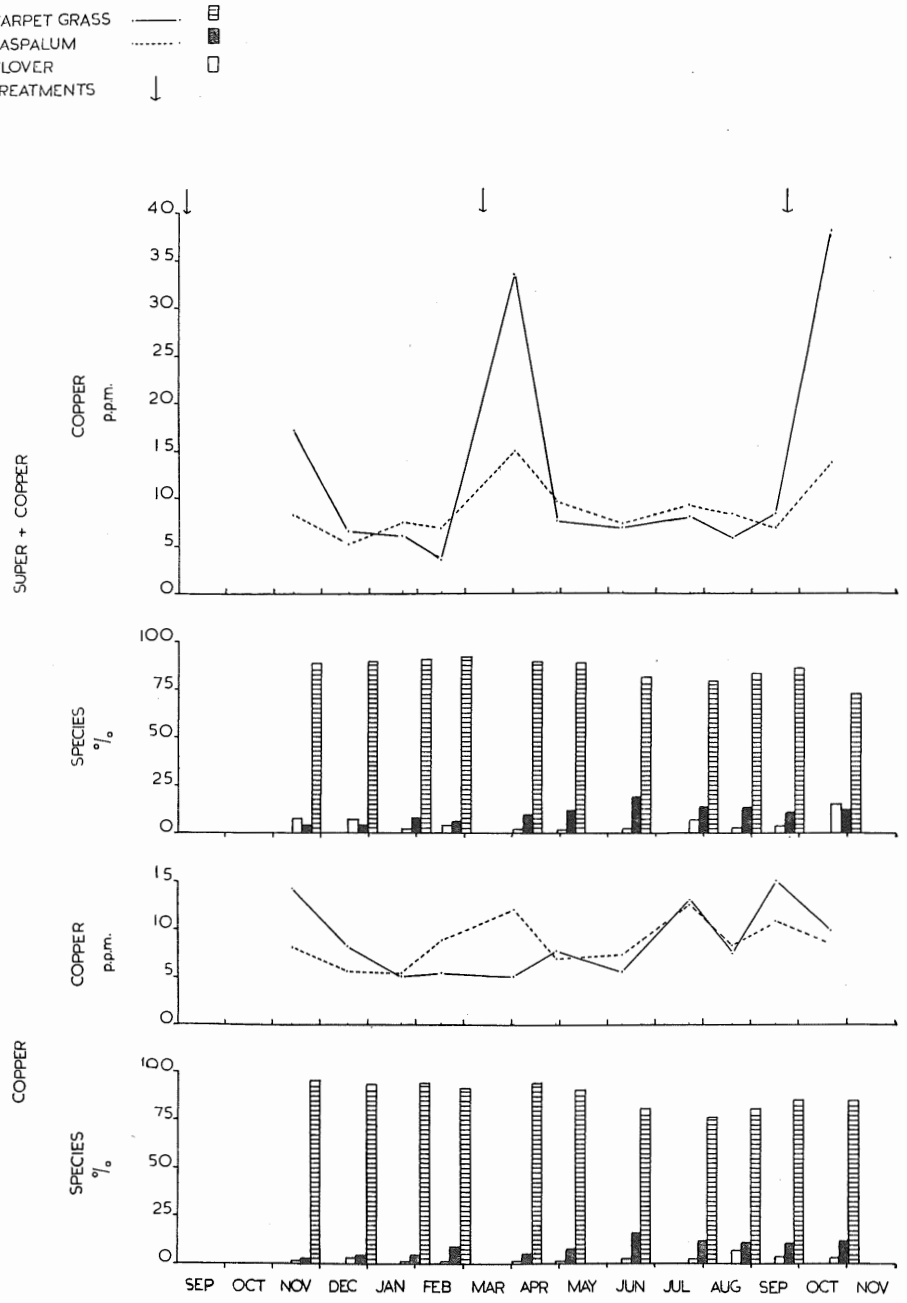

Fig. 3.

Copper Concentration and Botanical Composition of Pasture in Trial Paddocks 2 and 3 During 1953-54.

Paddock 2.—The pattern of copper uptake was similar to that in paddock 1. Carpet grass was dominant and the proportion of clover was low.

Paddock 3.—There was a less marked increase in the copper concentration in carpet grass following soil treatments. Here sawdust was used as a filler to distribute the copper sulphate. In paddocks 1 and 2, the superphosphate acted as the distributing agent for the copper sulphate. There is therefore an indication that for carpet grass, grown on soil where the available phosphate is low, additional phosphate may be necessary for maximum uptake of added copper sulphate. The initial uptake of copper by paspalum was similar to but less marked than in paddocks 1 and 2. Carpet grass was the dominant species, and the proportion of clover was negligible.

Paddock 4.—There were small seasonal variations in the copper content of pasture from this untreated area. Carpet grass was the dominant species. Its copper content was low, ranging from 2·5 to 5·5 p.p.m. Paspalum showed

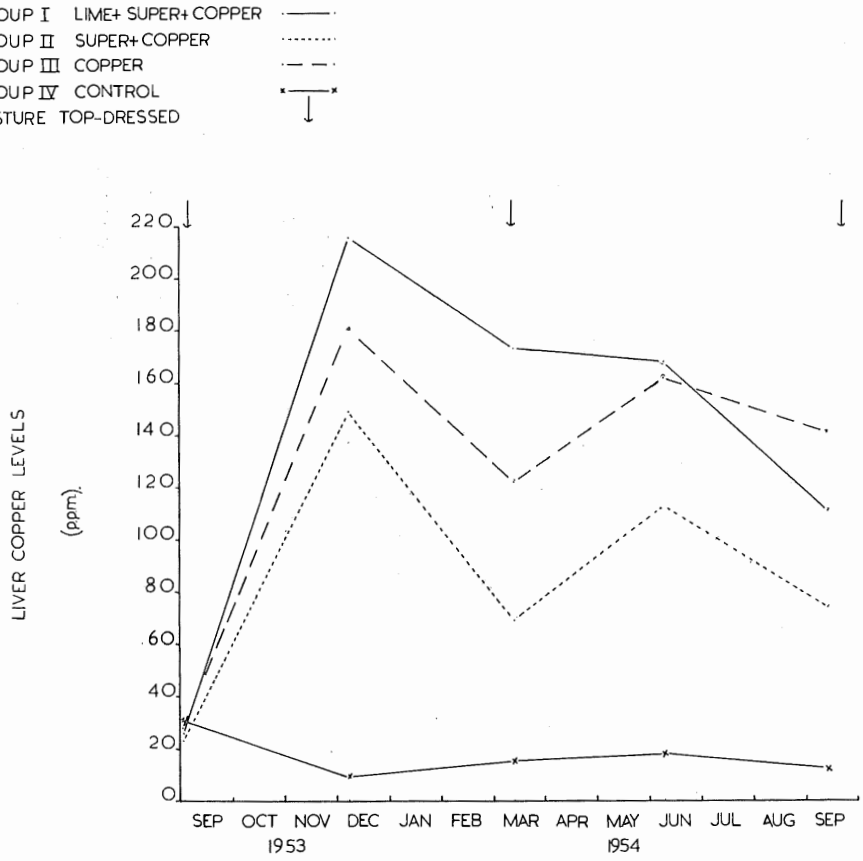

Fig. 4.

Mean Liver Copper Levels in Hereford Heifers from Each Group During 1953-54 Trial.

a slightly higher copper concentration (5–8 p.p.m.). Since the subdivision of this area in March 1951 an appreciable proportion of clover, ranging from 1 to 10 per cent., has been present in this paddock. This is greater than that recorded in paddocks 2 and 3 but considerably less than that found in paddock 1 (range 3 to 33 per cent.). The copper content of the clover varied from 6 to 13 p.p.m.

(b) Liver Copper.

Liver biopsy samples were taken at intervals of three months, the first samples being taken on Sept. 2, prior to topdressing on Sept. 5. The experimental animals were placed in their respective paddocks on Sept. 12.

The mean liver copper concentration of each group during the 1953-54 trial is shown in Fig. 4.

The liver copper concentrations were low in all experimental animals at the commencement of the trial, the range being 14 to 40 p.p.m. The animals grazing in paddocks 1, 2 and 3 showed a marked increase in liver copper concentrations at the December sampling and a decline at the March sampling. A further increase was shown at the June sampling following the second soil treatments on Mar. 11, 1954. The liver copper reserves had fallen again by September. Experimental animals from the control paddock showed an initial decline and for the ensuing nine months maintained a rather constant low level.

It is apparent, therefore, that under the seasonal conditions experienced the application of 14 lb. copper sulphate per acre at intervals of six months will maintain adequate copper reserves in grazing cattle.

(c) Pasture Phosphate.

The data from pasture phosphate analyses are presented in Fig. 5. Paspalum showed a higher phosphate content than carpet grass. There was a seasonal variation in the phosphate concentration in both species. In spite of topdressing with superphosphate, carpet grass in paddocks 1 and 2 showed a marginal to low phosphate status at the March-April sampling. In the untreated paddock (No. 4) carpet grass was deficient in phosphate at the January-February and March-April samplings. The phosphate level was good in the clover samples.

(d) Blood Inorganic Phosphate.

Blood inorganic phosphate analyses were made at intervals of three months on all animals from the experimental paddocks and on seven heifers of comparable age which were not confined to the trial area (see the copper therapy trial described below). The results are shown in Table 3.

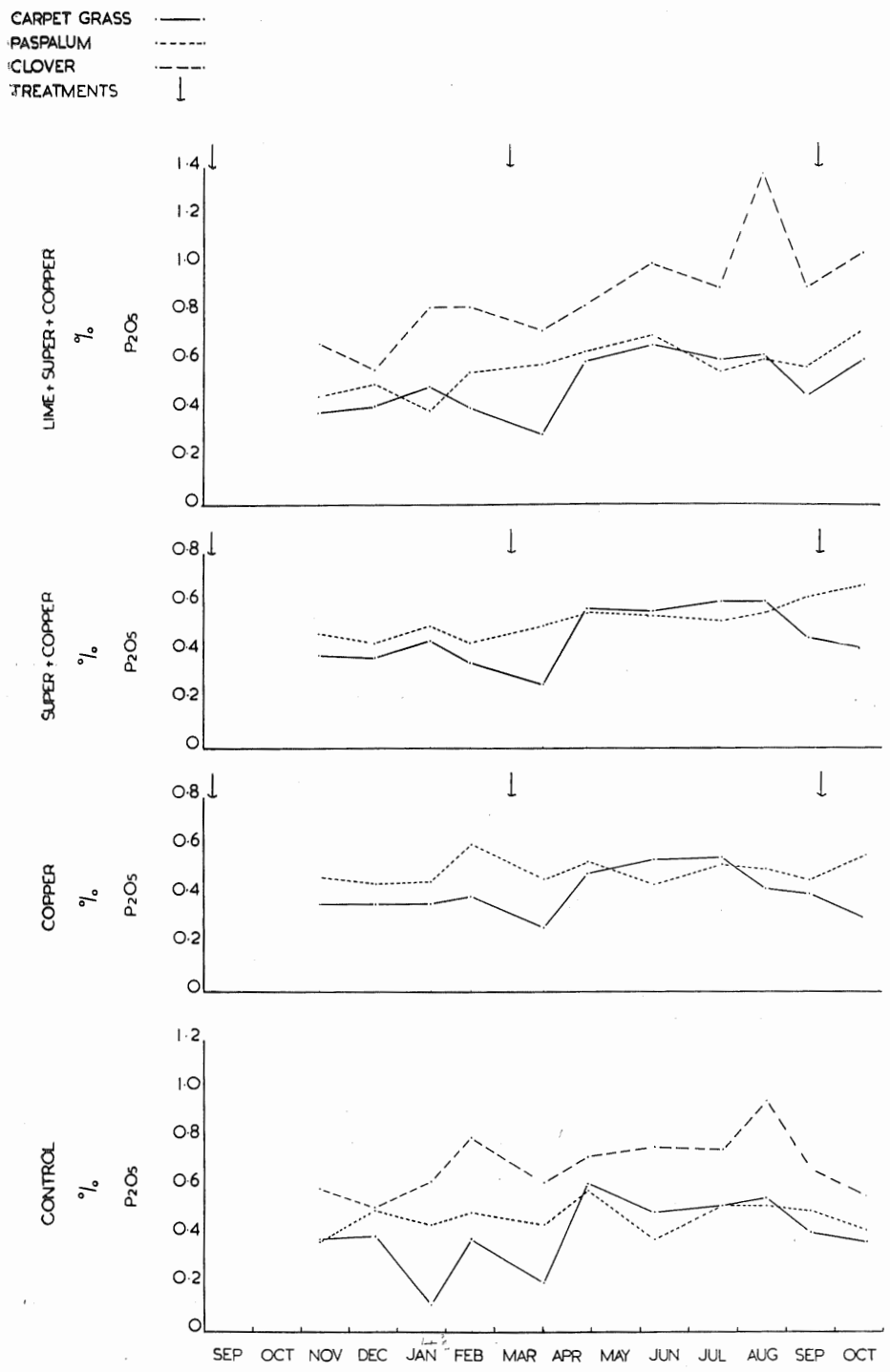

Fig. 5.

Phosphate Content of Pasture in Trial Paddocks During 1953-54.

Table 3.

BLOOD INORGANIC PHOSPHATE LEVELS IN HEREFORD HEIFERS DURING 1953-54 TRIALS.
(mg. P/100 ml.)

Sampling Date.	Paddock 1.		Paddock 2.		Paddock 3.		Paddock 4.		Outside Heifers—Copper Therapy Trial.	
	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.
Jan. 26, 1954	4·8–6·0 (0) *	5·4	4·7–6·2 (0)	5·4	4·1–5·1 (0)	4·8	4·1–4·7 (0)	4·7	..	..
Mar. 12, 1954	3·6–4·4 (1)	4·1	3·8–4·7 (1)	4·3	3·2–4·2 (3)	3·7	3·6–4·4 (1)	4·1	3·6–5·5 (2)	4·3
June 10, 1954	3·5–4·7 (1)	4·2	3·3–4·1 (2)	3·8	3·5–5·5 (2)	4·4	2·8–4·4 (1)	3·9	3·6–4·3 (5)	3·8
Sept. 13, 1954	3·3–4·0 (3)	3·5	3·4–4·5 (2)	4·3	3·9–4·8 (1)	4·4	2·8–5·2 (2)	3·8	3·9–5·2 (1)	4·6

* Figures in brackets indicate the number of animals from each group showing blood inorganic phosphate levels less than 4·0 mg. P/100 ml.

The blood inorganic phosphate status was satisfactory in January, but marginal to low in some animals from each group at the March, June and September samplings. It would therefore appear that for this predominantly carpet grass pasture, annual topdressing with 187 lb. superphosphate per acre does not ensure an adequate phosphate status in grazing cattle.

The annual applications of 187 lb. superphosphate were given to avoid expense on land used only for breeding. It is now known that heavy applications of superphosphate (1,120 lb. per acre) may give major changes in clover growth on the south-eastern coast of Queensland, and that these applications may remain effective for at least three years.

In animals from outside the experimental paddocks, phosphate deficiency was particularly evident in June, when five out of six animals examined showed borderline to low blood inorganic phosphate levels.

(e) Blood Haemoglobin.

This was recorded at intervals of three months. The mean levels in grams per 100 ml. of blood from experimental animals ranged from 12·1 to 12·7 in paddock 1, 11·8 to 9·9 in paddock 2, 11·8 to 9·3 in paddock 3 and 11·0 to 10·2 in paddock 4. Thus there was no correlation between haemoglobin levels and liver copper reserves.

(f) Rainfall.

The monthly rainfall during the experimental period is shown in Table 2. This was an unusually wet year with maximum falls in February and July, when 24·77 and 12·60 in. were recorded. Flooding of the experimental paddocks followed the February rains, necessitating the removal of all experimental heifers for two weeks.

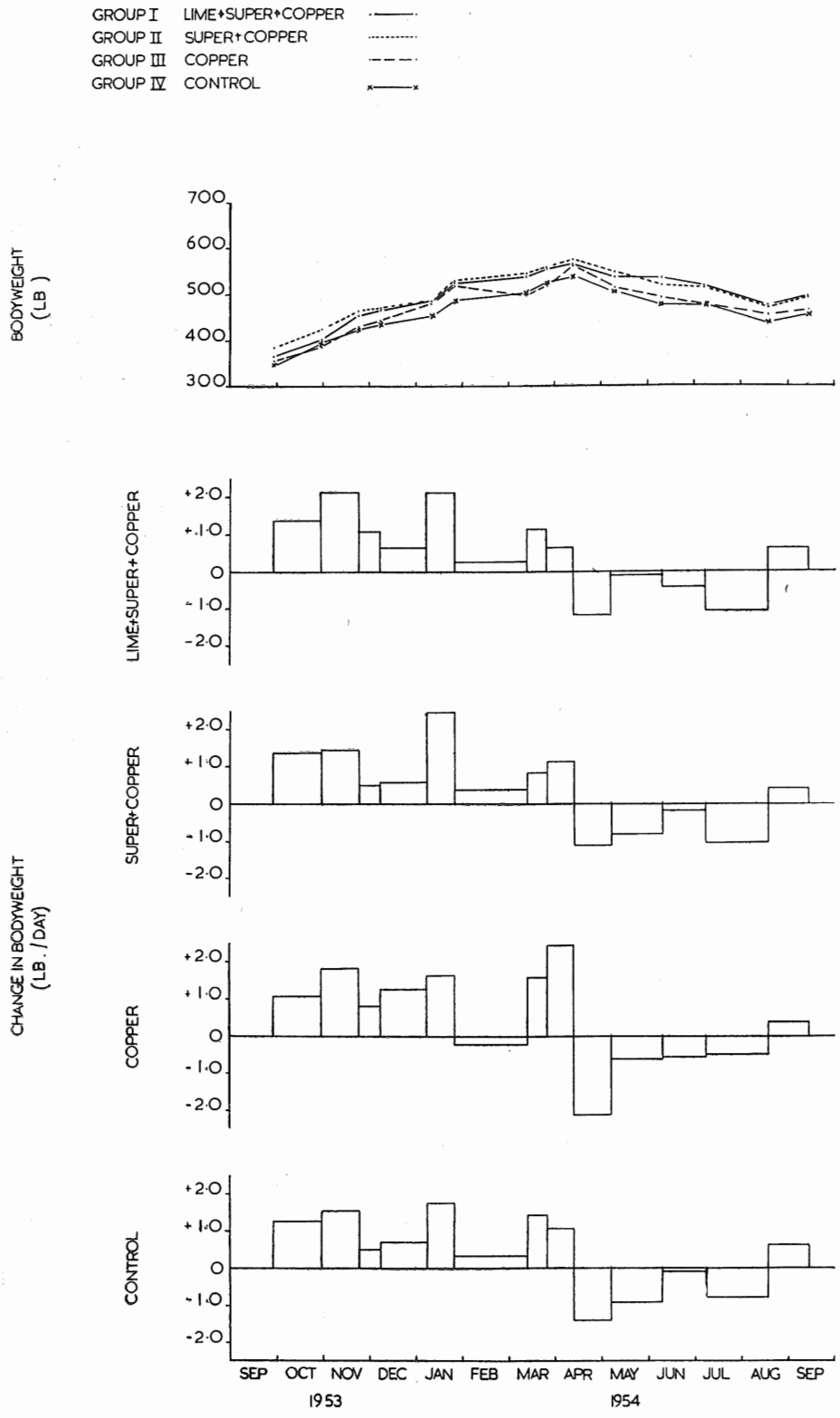

Fig. 6.

Mean Bodyweight Changes in Hereford Heifers from Each Group During 1953-54 Trial.

(g) Liveweight.

The liveweights of the experimental heifers are shown in Fig. 6. During the 12 months of the experiment the increases ranged from 360 lb. to 475 lb. The mean daily gains for the groups were:—

Group 1—0·38 lb. per head per day.
Group 2—0·31 lb. per head per day.
Group 3—0·32 lb. per head per day.
Group 4—0·30 lb. per head per day.

The heifers gained weight from the commencement of the trial until April, lost weight until August and had started to gain weight in September. It is evident that there is no difference between groups with respect to either summer-autumn gains or winter losses. Since the three groups grazing topdressed paddocks had normal liver copper concentrations, whereas group 4 was deficient, it is concluded that copper deficiency is not the only factor limiting the growth of cattle on this property.

The blood inorganic phosphate status was unsatisfactory in all groups from March to September, 1954, so deficiency of phosphate as well as copper could play some part in limiting growth of cattle on this property.

Ample and well distributed rain during 1954 resulted in above-average growth of pasture for this area, but it was observed that cattle grazed very little, at least during the day, during the period April to August. Quantitative observations on grazing times, feed intakes and yields of pasture dry matter were not made, but from inspection of the pastures and the cattle, one could not escape the conclusion that failure to consume the available pasture was an important cause of the pronounced loss in weight of the experimental heifers during winter and early spring. The syndrome of scouring, emaciation and weakness, that caused heavy losses in the wet winter of 1950, was prevalent in 1954 in the herd outside the experimental paddocks, where it again caused losses among cows, calves and yearlings. It has yet to be determined why, during apparently favourable seasons, cattle should show reduced appetite and exhibit this syndrome.

(3) Conclusions.

Topdressing with copper sulphate at 28 lb. per acre per annum in two applications each of 14 lb. per acre at intervals of six months enables grazing cattle on this predominantly carpet grass pasture to accumulate and maintain adequate liver copper reserves.

Carpet grass shows a marked increase in copper concentration following soil treatment in paddocks 1 and 2, where superphosphate was applied with the copper sulphate. This level also falls sharply. Paspalum shows a less marked but more prolonged rise, so residual copper concentrations tend to be higher in

this species. Clover shows a similar pattern. In paddock 3 the increases in copper concentration in both carpet grass and paspalum are less marked, but the raised copper levels tend to persist longer.

As in the 1951-53 trial, the proportion of clover is greatest in paddock 1, ranging from 31 per cent. in November to 3 per cent. in April and up to 30 per cent. in June. This may be attributed to the lime applied in March 1951. In paddock 2 the proportion of clover ranged from 1 to 15 per cent. Paddock 3 had from 1 to 3 per cent. and paddock 4 from 2 to 10 per cent. clover.

Soil treatments with lime, superphosphate and copper, alone or in combination, did not improve weight gains of heifers grazing this pasture during 1953-54. All groups showed marked weight losses during the period April to September. It would therefore appear that copper deficiency, which is evident from the low copper levels in livers from animals in the untreated control paddock 4, is not the only factor limiting the growth of cattle on this property.

Blood inorganic phosphate analyses indicate an unsatisfactory phosphate status in cattle from March to September. Even in the phosphate-treated paddocks 1 and 2, the phosphate content of the predominant carpet grass would be inadequate in the March-April period. It is therefore possible that phosphate as well as copper deficiency could be a factor limiting the growth of cattle on this property from April to September.

Observations on experimental heifers as well as pastures suggest that failure to eat the available pasture is an important cause of the pronounced loss in weight of the animals during winter and early spring. As in 1950, there were heavy losses in cattle outside the experimental paddocks. It would appear that the syndrome of scouring, emaciation and weakness, which in 1950 led to the initiation of these trials, may be a feature in years of unusually high winter rainfall in this locality.

IV. SUPPLEMENTARY TRIALS IN 1953-54.

(1) Copper Therapy Trial.

Seven heifers remaining after selection of the 16 heifers for the previous trial were divided into two groups. Three animals received 50 mg. copper subcutaneously as copper glycinate (aminoacetate) and four animals were treated intravenously with 25 mg. copper as copper sulphate. Treatments were repeated at intervals of three months and in the latter group the dose was subsequently increased to 50 mg. copper. The animals were allowed to run with the remainer of the herd on this property. At intervals of three months they were mustered for liver biopsy, weighing and retreatment.

(a) Results.

Liver copper levels in the copper glycinate group averaged 70 p.p.m. at the commencement of the trial and 85 p.p.m. at its conclusion 12 months later. Liver copper levels in the copper sulphate group averaged 70 p.p.m. at the beginning and 170 p.p.m. at the end of the period. This initial average of 70 p.p.m. was considerably higher than the initial average in heifers in the 1953-54 trial. It was due to parenteral copper therapy in some animals prior to the commencement of the supplementary trial.

Blood phosphate levels were unsatisfactory in some animals at the March, June and September samplings (Table 3). In June, five out of six animals tested showed marginal to low blood inorganic phosphate levels.

Liveweight changes for each group are shown in Fig. 7.

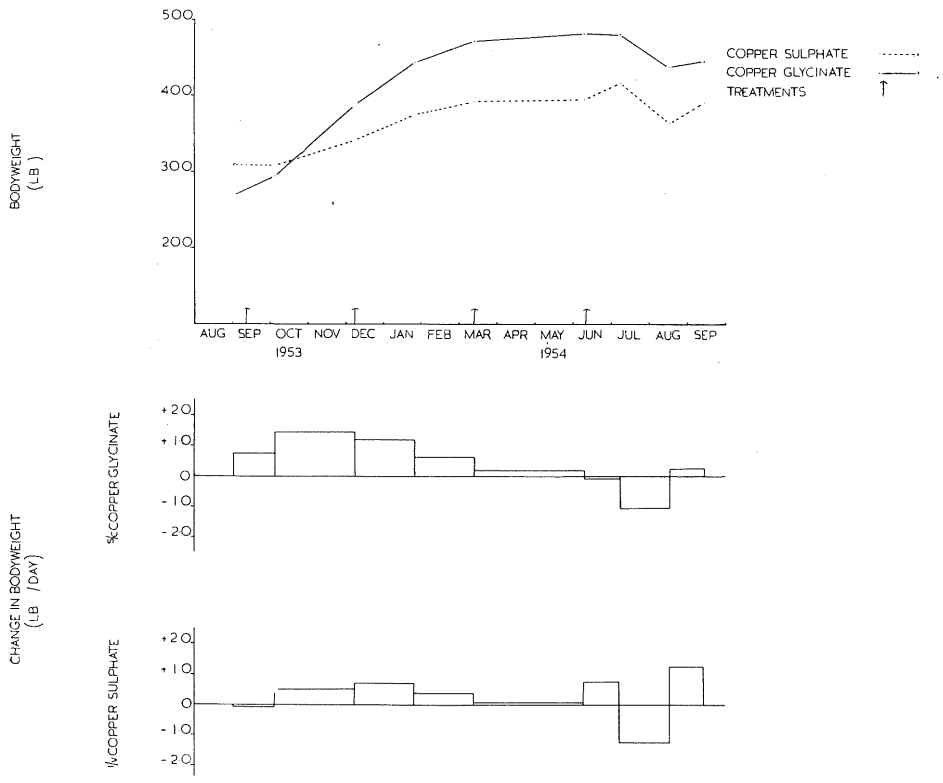

Fig. 7.

Mean Bodyweight Changes in Hereford Heifers from Copper Therapy Trial.

(b) Conclusion.

For these animals and for this season, treatment with parenterally administered copper every third month was sufficient to maintain adequate liver copper reserves. Weight gains were not satisfactory, particularly during the later months of the trial; they showed a pattern similar to that of the heifers in the four experimental paddocks described above.

It is apparent that, as in the previous trial, copper deficiency alone is not the factor limiting the growth of cattle on this property.

(2) Pasture Topdressing Trial.

Ten plots of pasture, each ½ square chain in area, were selected adjacent to the four experimental paddocks. The following treatments were laid down in duplicate on Sept. 5, 1953:—

(*a*) Treatment with calcium, phosphorus, and trace elements, viz.:

	lb. per acre.
Ground limestone	2,240
Superphosphate	112
Borax	1½
Copper sulphate	14
Zinc sulphate	7
Manganese sulphate	14
Magnesium sulphate	56

(*b*) As for (*a*) but without limestone.

(*c*) Superphosphate 224 lb. per acre, plus copper sulphate 14 lb. per acre.

(*d*) Superphosphate 224 lb. per acre plus copper sulphate 28 lb. per acre.

(*e*) Copper sulphate 56 lb. per acre.

The pasture was similar to that in the adjoining experimental paddocks already described—i.e. predominantly narrow-leaved carpet grass with 1–5 per cent. paspalum. The amount of clover was negligible. From each plot a single sample of pasture was collected and hand-sorted into species. Samples were taken monthly from Nov. 12.

(a) Results.

The results of copper analyses are shown graphically in Fig. 8. The copper concentration in each pasture species from each treatment is the mean of two levels obtained from samples from the duplicate plots.

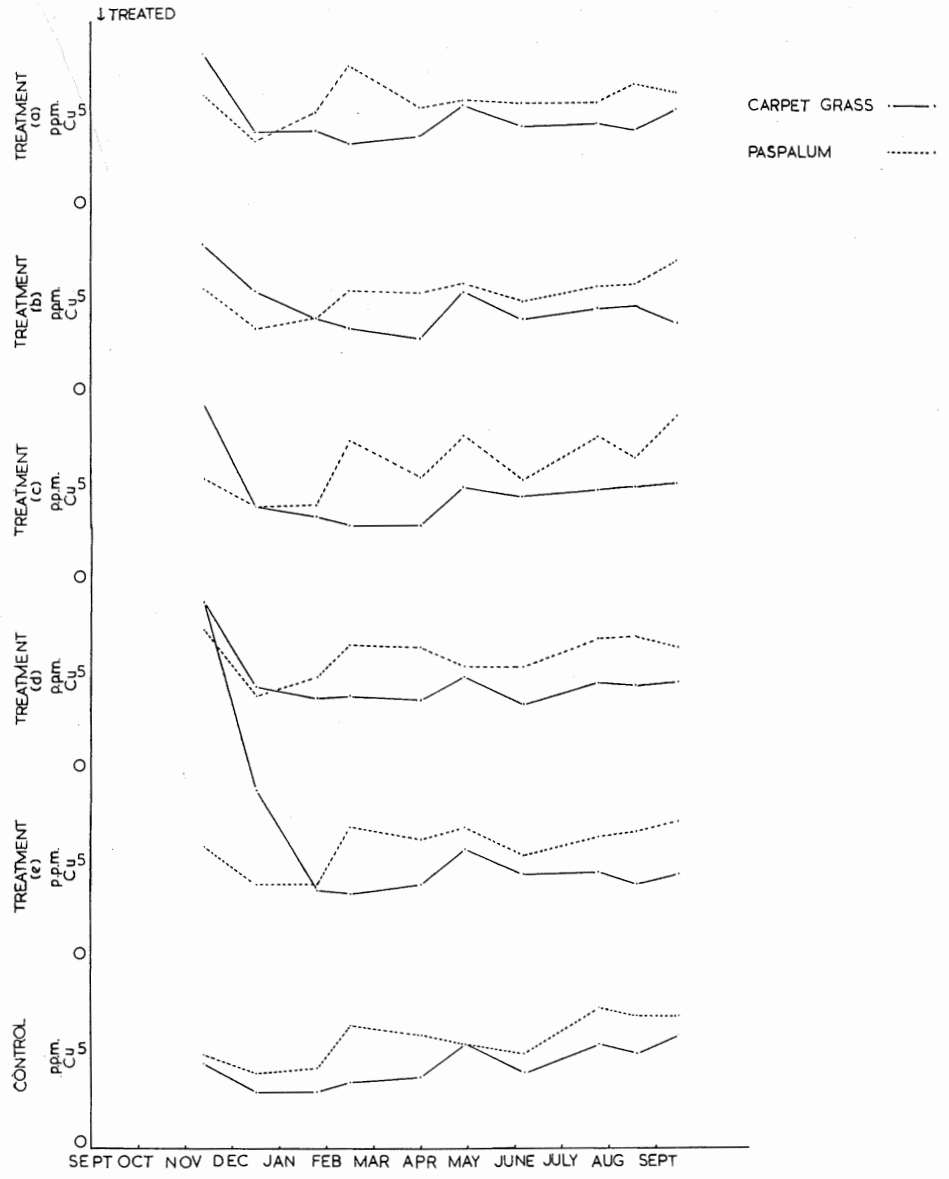

Fig. 8.

Copper Content of Carpet Grass and Paspalum from the Supplementary Pasture Topdressing Trial.

The copper concentration in carpet grass and in paspalum from these plots showed a pattern similar to that of pasture in the experimental paddocks already described. There was an increase in the copper content of carpet grass from the treated areas at the November sampling, two months after treatment.

This increase was most marked where the treatment was 56 lb. copper sulphate per acre (plot e). In December, the copper concentration in the carpet grass had fallen in all except plot e to a level comparable with that found in carpet grass from the untreated areas. In January and at all subsequent samplings until the end of the trial in September, the copper concentration in carpet grass was low irrespective of soil treatment. A similar pattern was shown by paspalum, except that the increase in copper concentration at the November sampling was less marked.

These experimental pasture plots were not grazed. The pasture management, therefore, did not favour the growth of clover. The duration of the trial was only 12 months. No significant changes in botanical composition were noted.

(b) Conclusion.

For this area the response from copper treatment, in terms of copper content of carpet grass or paspalum, does not persist for longer than four months, irrespective of the amount of copper sulphate added (up to 56 lb. per acre). Where copper sulphate was added at 14 lb. or 28 lb. per acre an increase in copper content of the predominant pasture could not be detected at sampling three months after treatment.

The fertilizer treatment with calcium, phosphorus and trace elements (plot a) did not influence the availability of added copper two and three months after topdressing.

The data from this trial, together with those from the 1953-54 grazing trial, support the conclusion that soil treatment with copper sulphate at the rate of 28 lb. per acre per annum applied in two topdressings six months apart is necessary to maintain an adequate copper status in cattle grazing on this property.

This rate and frequency of topdressing is heavy in comparison with that found necessary in other copper-deficient areas. In South Australia, topdressing with copper sulphate at the rate of 7 lb. per acre per annum is recommended (Marston 1951). In New Zealand, Cunningham (1951) stated, the most satisfactory method of control is topdressing with 5 lb. copper sulphate per acre each autumn. Gilbert (1952), in reviewing the data on residual effect of added copper on different soil types, stated that copper applications must be made more frequently on heavier soils and on sandy soils subject to excessive leaching. Teakle (1942) showed that when as little as 3 to 10 lb. of copper sulphate per acre was applied on sandy soils in Western Australia, it was unnecessary to add further copper sulphate for at least another year.

The necessity for heavy and frequent topdressing with copper sulphate to ensure an adequate copper status in grazing cattle on this property may be related partly to poor retention of copper by the dominant pasture species

(*Axonopus affinis*) and partly to the high rainfall (averaging 69.8 in. per annum for the three years of the trial) in an area where the soil structure is poorly developed.

(3) Cobalt Therapy Trial.

At the conclusion of the 1953-54 trial in September, the 16 heifers were paired as well as possible in terms of weight. One member of each pair was dosed by mouth with 2 fl. oz. of a solution containing 2 oz. cobalt chloride per gallon. Treatment was given twice during the first week and thereafter weekly. Liveweights were recorded fortnightly. The duration of the trial was eight weeks.

Liveweight differences did not permit a satisfactory pairing of animals, and there was a large within-group variation which vitiated statistical analyses. The mean weight gain for the cobalt-supplemented group for the trial period of eight weeks was 81 lb. (range 56-102 lb.) and for the untreated control group 62 lb. (range 16-89 lb.). This trend in favour of the cobalt-supplemented group warrants further investigation, particularly during the winter months, when stock on this property lose weight.

V. GENERAL CONCLUSIONS.

The main findings from the trial on this property are as follows:—

(1.) Topdressing with copper sulphate every six months at the rate of 14 lb. per acre is necessary to ensure an adequate copper status in grazing cattle. This is an unusually high requirement and may be related partly to the poor retention of copper by the predominant pasture species (narrow-leaved carpet grass) and partly to the high annual rainfall in an area where the soil structure is poorly developed.

(2.) Narrow-leaved carpet grass shows a large (up to 30 p.p.m. Cu) and rapid uptake of copper following topdressing with copper sulphate plus superphosphate. There is also a rapid decline in copper content.

(3.) The addition of copper sulphate at the rate of either 28 lb. or 56 lb. per acre does not give a longer persistence of copper in carpet grass than that obtained from topdressing with 14 lb. per acre.

(4.) Paspalum and white clover growing on the same soils under the same conditions maintain a higher average level of copper than narrow-leaved carpet grass. The very low proportion of these species in the pasture prevents them from making any significant contribution to the animals' diet.

(5.) The data on liveweight show that cattle with adequate liver copper gained no better in summer-autumn and lost no less in winter than the copper-inadequate control animals.

(6.) All animals had an unsatisfactory blood inorganic phosphate status, particularly during the winter months.

(7.) Topdressing with superphosphate at the rate of 187 lb. per acre per annum did not markedly improve the blood inorganic phosphate status in cattle grazing this pasture.

(8.) Liver copper reserves were maintained in Hereford heifers weighing 300 lb. by injections of 50 mg. copper as glycinate subcutaneously or as sulphate intravenously every three months.

(9.) Only in the area on which ground limestone was applied at 1 ton per acre was there any marked change in the botanical composition of the pasture. Here up to 33 per cent. white clover was found associated with the predominant narrow-leaved carpet grass.

(10.) Cobalt-supplemented cattle during the period September-November tended to make more satisfactory weight gains than untreated animals.

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