I wish to acknowledge that the work reported in this thesis forms part of a programme of work financed by the Agricultural Research Council. With the exception of Section 1 the results have been submitted to the Council.

To Professor S.J. Watson I am especially indebted for his most helpful supervision, constant encouragement and detailed interest in the investigation. Also to his staff, Mr. J. M. M. Cunningham and numerous others, for help in various ways, particularly in providing facilities on the School of Agriculture farms. I am very grateful to Dr. A. M. Smith, Mr. P. McDonald and Mr. A Campbell for so kindly arranging the essential chemical analyses and digestibility trials, to Dr. J. Hussey for advice on some novel meteorological aspects of the investigation and to Mr. M. A. Knox for valuable comments on the script.

My thanks are also due to the Meteorological Office, Air Ministry, London for summarised information on weather, to Messrs. Block and Anderson, 31 Montrose Terrace, Edinburgh 7 for reproduction of the graphs and to the Shearmow Harvester Company Limited, 66 Victoria Street, London, S.W.1. for the loan of a prototype forage harvester.

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INTRODUCTION

There is abundant evidence to show that in Britain large quantities of silage are produced containing high contents of moisture and that, until recently, little attention has been paid to the advantages gained by ensiling less succulent herbage. In S. E. Scotland, as in other parts of Britain, wet silages are frequently produced, a wet silage being regarded as one which contains more than 80 per cent moisture. Although it is generally agreed that the best results are obtained when a silo is filled with dry material it is still a common practice for very wet herbage to be ensiled and for partly filled silos to be left uncovered and hence exposed to rain.

Wet silages, undesirable on account of their low content of dry matter, large nutrient losses, reduced quality and offensive odour, are, of course, produced not only as a result of ensiling wet herbage but also from seepage of rain and ground water into silos during the autumn and winter months. It is not surprising, therefore, that stress is being laid on the importance of providing better protection to silage, particularly by means of a roof. Roofed silos have demonstrated that the dry matter content of the ensiled herbage can

be maintained at its original level. The fact that an unroofed silo loses the advantages otherwise to be gained from new field techniques has yet to be appreciated.

On farms abroad the technique of admixing chopped hay, straw or other dry substance with succulent greenstuff to raise the dry matter content of the whole is considered a useful procedure. But this practice is only satisfactory when proper chopping and mixing machines are available. On British farms it is still usual to ensile herbage in an unchopped condition and hence few attempts are made to mix one crop with another.

A second and probably easier method of raising the dry matter content of green crops is by field wilting. In recent years a large number of experiments on wilting have been conducted in both America and Europe and the following advantages are claimed for the process: (1) the chance of producing sour or evil-smelling silage with its associated butyric acid and proteolysis is greatly reduced and hence quality and palatability are maintained; (2) there is little if any effluent seepage and total nutrient losses, particularly with respect to digestible crude protein, are less than in ordinary silage; (3) dry silage chills less than wet silage under low temperature conditions in winter; (4) for a given quantity of wilted

silage the amount of dry matter consumed by farm animals is greater than that from a similar quantity of bulky wet material; (5) silos are more economic in that they hold greater quantities of dry matter; (6) wilting causes a reduction in crop weight and, therefore, less man-hours are required for transporting loads to the silo and for making and utilizing the silage; (7) it is not essential to use machinery other than that normally employed in the field.

In Britain only a small number of farmers produce wilted silage so that information from a farm source is limited. Likewise little experimental work has been carried out on wilting at research stations, an understandable fact since the practicability of the wilting process under British conditions of weather and silage-making has often been doubted.

The main difficulties usually associated with the making of wilted silage are as follows: (1) it would be unlikely for the weather to remain fine during the entire period of filling a silo; (2) if wilting was prolonged, or if the herbage were harvested at a late and therefore stemmy stage of growth, there would be a danger of producing over-heated silage of reduced digestibility; (3) it would not be easy to organise field work owing to the need for providing the silo with a

regular flow of herbage wilted to the correct stage; (4) almost all the modern types of forage harvester are designed for use on standing crops, and not on herbage which is already in the form of swathes, so that the wilting process could not be practised on many highly mechanised farms. The above points suggest that wilting for silage would not only be a risky process, and one which would hardly fit in with present methods of harvesting, but that it would also increase the chances of producing a foodstuff of lowered digestibility.

At present there is no satisfactory evidence to show that good silage of higher than normal dry matter content could not be made in trench silos, assuming that equipment of a suitable type is available for the work. Further there is no information to show how much overheating has to occur before a silage of moderately high dry matter content becomes of less value to the animal than a wet silage produced at a normal temperature range, weight for weight.

In the United States where crops are chopped and where large upright silos are still widely used, herbage containing moisture contents of 60 to 65 per cent can be safely ensiled. In the Netherlands, where small upright silos are sometimes employed, it has been found possible to make good silage from long herbage containing

the very low moisture content of 50 per cent; though, to prevent overheating, each silo must be filled in one day and immediately covered with a thick layer of soil. In Britain the normal practice is to employ horizontal silos of relatively large capacity which require a filling period of from one to two weeks. It follows, therefore, that under British conditions of silage-making the level of moisture content at which it would be safe to ensile wilted grass without the occurrence of overheating would probably be less than the figures mentioned above.

It is already known that unchopped stemmy grass, nearing the hay stage and containing a moisture content of the order of 70 per cent, can be ensiled satisfactorily in trench silos provided the material is adequately consolidated, and this gives a useful indication of the moisture level at which to aim. Thus if it were possible to lower the moisture content of succulent semi-leafy herbage from 80 to 85 per cent to 70 to 75 per cent moisture, during moderate periods of wilting, then drier silage would be produced containing a much greater amount of dry matter compared to that in ordinary silage.

Bearing these points in mind it was decided in 1953 to conduct an investigation on the partial wilting process over a period of three

seasons. The work was carried out in three stages. The first stage entailed simple field trials which were carried out with the object of determining the extent to which grass-clover herbage will wilt under varying conditions of weather, crop and field technique. The trials were mostly performed with long herbage though, in view of the lack of information on the possibilities of a combined mechanical and wilting treatment, a few trials were conducted with material which had been both bruised and wilted.

The second part of the investigation entailed the making of wilted silage in small experimental silos from both long and bruised herbage. A few of the silages were made with molasses and sodium metabisulphite. The final products were examined for quality, losses and digestibility, and compared with silages made from ordinary low dry matter material. No quantitative experiments were conducted to determine the value of the various silages for production of meat or milk. The final stage of the work was carried out on a farm scale in order to study the practical problems associated with the making of wilted silage in trench silos. The farm silages were made in one season only, 1955, but fortunately the occurrence of extreme weather conditions during part of the ensiling period enabled information to be obtained which otherwise might not have been secured.

Details and results of the experimental

findings are given in sections II, III and IV of this thesis. All basic data are tabulated in section V. Section I with the accompanying bibliography consists of a review of investigations carried out during the last hundred years on the production and utilization of wilted silage.

SECTION I.

REVIEW OF LITERATURE, WITH BIBLIOGRAPHY

One of the earliest references to the wilting process is that of Reihlen (1865), in Germany who stated that his method was to leave the cut green crop, maize, exposed in the field for one or two days prior to filling into a pit along with salt as a preserving agent. Moser (1879) in Austria, also working with maize, observed that a few days of wilting followed by conserving in conical heaps produced a silage of improved quality. In Britain, Voelcker (1883) was one of the first to discover that grass crops or arable crops such as tares or vetches, could not be preserved successfully if the moisture content exceeded 80 per cent. Wagner (1886) emphasised the importance of heavy tramping to prevent mould formation, though it is interesting to note that the silages were classed as 'sweet and very palatable to stock'. Wagner made no mention of overheating occurring in the silo which suggests that in the early days little was known of the relationship between the temperature and digestibility of silage. Meissl (1889), also realised the importance of consolidation and found that good quality maize silage could be produced when the material was mechanically compressed. In America investigations by Babcock

and Russell (1900) showed the unsuitability of high moisture crops for silage. The results indicated that nutrient losses were greater the more sappy and unripe the material. The large losses were attributed to the greater activity of protoplasm in immature plant material. Feeding trials were also being conducted during the early years and one of the first was that carried out by Thiel (1887) who compared hay and wilted silage for dairy cows.

The foregoing indicates that at the end of the last century investigators were already seeking answers to problems connected with the quality of silage. The fact that silages were sometimes made from pre-wilted crops suggests that moisture content was considered a factor of probable major importance, a point agreed upon by many later workers who, as will be seen, have conducted a large number of silage experiments using crops of controlled moisture content.

The following review is primarily centred on the grass crop, using the term in its widest sense, and is set out under the following six main heads: (1) the chemical and physical changes in wilted and fresh herbage (2) wilting in practice (3) moisture contents of wilted and fresh silage (4) quality, digestibility and losses of wilted silage (5) treatments additional to wilting and

(6) the feeding of high and low dry matter silages.

CHEMICAL AND PHYSICAL CHANGES IN WILTED AND FRESH HERBAGE.

CHEMICAL CHANGES

Dry matter.

In a review on the changes which occur in forage following cutting Watson (1952) states that 'all the evidence tends to show that marked changes take place, as might well be expected, since the process of respiration continues and the enzymes are still active.' Watson refers to the work of Fleischmann (1912) who determined the changes occurring in the dry matter content of grass during drying. With wilting periods greater than one day Fleischmann obtained a loss of dry matter, irrespective of weather conditions, but when the grass was subjected to bright sunshine for one day actual gains of from 2 to 5 per cent. took place. The gains were attributed to continuation of photosynthesis after cutting.

Greenhill (1933) showed that in grass herbage dry matter losses of up to 12 per cent. took place during wilting periods of 7 to 14 days, i.e. a loss of about 1 to 2 per cent. per day. In later experiments, however, Greenhill (1936) found no significant loss of dry matter in pasture grass wilted for 4¼ days during weather conditions

suitable for drying. Mihin and Tupikova (1940), on the other hand, found losses of 12 to 17 per cent. in grass wilted for 3 to 4 days, so that here there was a daily loss of approximately 4 per cent. Crasemann and Heinzl (1949), in a general statement on dry matter losses, mention a figure of up to 3 per cent. per day which agrees with the results of Bosch and Deijs (1950); 2.5 - 3.0 per cent. per day. Bosch and Deijs showed that if wilting did not exceed 48 hours then there was no serious reduction in value of the herbage. Dijkstra (1952) found losses ranging between 12.3 and 13.3 per cent. in high-protein grass during 5 days so that here again it could be said that there was a daily loss of about 2.5 per cent. Flieg (1952) stated that field losses may be less than might be imagined because there is always a possibility of some carbon assimilation. Sutter (1955) found losses of 0 to 2 per cent. in 24 hours while Dijkstra and Brandsma (1955) reported losses of 2.3 per cent. after 4 days, 10.4 per cent. after 8 days, 6.4 per cent. after 5 days and 7.3 per cent. after 12 days. Here, therefore, the daily loss was approximately 0.5 to 1.0 per cent. In one experiment there was an actual increase amounting to 0.6 per cent., though the workers ascribe it to an experimental error. One final reference may be made, that of Murdoch (1955)

who found slightly greater losses, 2.5 to 4.2 per cent. after 24 hours wilting though in one trial there was a gain of 0.5 per cent. After 48 hours losses of 1.7 to 6.3 per cent. were obtained.

Consideration of the above results indicates that provided wilting is carried out for no longer than 24 hours then little dry matter loss will occur.

Carbohydrate.

The changes occurring in dry matter content of grass crops have also been studied. As regards the carbohydrate fraction Stone, Reid and Bechdel (1944), working with lucerne found an increase in fermentable sugar during wilting while Kivimäe (1953) found that the sugar content increased by 4 to 7 per cent when the dry matter content was raised from 10 to 20 per cent. to 35 to 50 per cent. Similar increases were obtained in red clover and pasture grass. Wylam (1953) experimenting with S.24 ryegrass found that about 46 per cent. of fructosan was hydrolysed after 24 hours wilting, by which time the dry matter content of the grass had reached 45 per cent. Berezovskiĭ and Egorova (1949) clain an increase by hydrolytic action.

Protein.

Wilting has been shown by Fleischmann (1912) to cause a break-down of true protein into simpler

substances though it did not cause an actual loss of protein. Greenhill (1933) also found a break-down of the so called "true" protein (copper - precipitable nitrogen x 6.25) of 28 per cent. after 2 days. Later, Greenhill (1936) found that the wilting of grass during periods up to 4¼ days had little effect on percentage crude protein, nor was there any significant change in the content of pepsin - digestible nitrogen in the dry matter. Fagan and Ashton (1938) and Fagan and Davies (1939) reported negligible change in the total nitrogen content of grass wilted for as long as 12 days, even during wet weather conditions. Eriksson (1953) found only a slight decrease in protein percentage in lucerne wilted to 30 to 35 per cent. dry matter, and negligible change has also been reported by Dijkstra and Brandsma (1955) who tested high-protein grass. But earlier Dijkstra (1952) had calculated that the actual loss of crude protein in protein-rich grass, wilted for 5 days, was of the order of 5 to 9 per cent. Macpherson (1952) examined both young grass and mature grass and found that 16 per cent of true protein was broken down into simpler substances after 24 hours wilting during which time the dry matter increased from 24 to 41 per cent. There was no actual loss of protein.

Carotene.

Probably the greatest change which occurs during wilting concerns the carotene fraction. Relatively large losses of this constituent may easily take place. Greenhill (1936) claimed a loss of 14 per cent. after 6 hours and 22 per cent. after 4¼ days. Greenhill points out, however, that from the nutritive point of view the losses were not serious, the actual amount of carotene remaining after 4¼ days still being adequate for nutrition. Fagan and Ashton (1938) found that during good weather carotene loss in grass was only slight but that wet weather had a marked affect. A loss of 10 to 27 per cent. was recorded after 24 hours and 24 to 31 per cent. after 48 hours. Fagan and Davies (1939), in later experiments, found that carotene loss was greater in grass originally rich in this constituent. Bosch and Deijs (1950) claimed a loss of 10 per cent. in grass after 1 day's wilting and in the case of lucerne, 15 per cent. Martin, Stoddard and Porter (1952) working with lucerne found a significant carotene loss after only 1½ hours, while Waite and Sastry (1949) working with mixed ryegrass and timothy found that during fine weather the loss amounted to 10-15 per cent. after 2 to 3 hours. The loss was less during cold and semi-cloudy conditions. Eriksson (1953) and

Axelsson and Kivimäe (1955) also reported carotene losses during wilting.

PHYSICAL CHANGES.

In his review Watson (1952) states that after a crop is cut the most obvious change which takes place is the physical loss of moisture, but points out that before the crop is cut the question of diurnal variation has to be faced even though there is much doubt as to its magnitude.

Diurnal variation.

Willard (1929-30) showed that evaporation of dew from legumes did not account for more than 3 per cent. of moisture. Greenhill (1936a) obtained similar results. Grass plots were cut over a period of 5 days during varying weather conditions. Percentage moisture of the herbage fell significantly throughout the day. The average moisture content at 9.30 a.m. was 81.5 per cent. By midday it had dropped to 78.9 per cent. and to 78.1 per cent. by 3 p.m. giving an average overall drop of 3.4 per cent. units. Greenhill attributed the moisture reduction almost entirely to the disappearance of external moisture, usually present on the herbage early in the morning. If the grass contained any appreciable amount of external moisture in the early morning then most of this had disappeared by about midday. Hence the most suitable time

for cutting grass was from about noon, or a little earlier, to 3 p.m. If the grass was free of external moisture initially in the morning then there was little advantage in postponing cutting until late in the day. Woodward and Tysdal (1944) on the other hand found there was little benefit in cutting crops during the afternoon compared to early morning and disagreed with Curtis (1944) who, expressing his results in terms of dry matter, stated that there was a dry matter yield 19 per cent. higher in the afternoon than in the morning cuttings. Dexter (1945) likewise could not confirm the large increase in dry matter reported by Curtis though some of the results showed a moisture drop of 1 per cent. between 8 a.m. and 4 p.m. In contrast, Morrison, Stephenson and Brown (1953) obtained a dry matter increase of 7 per cent. during a sunny day with grass initially wet with dew. It is interesting to note that Crasemann and Heinzl (1949) classified grass according to its wetness, 'dripping wet' grass containing as little as 14.4 per cent. dry matter, grass 'moist with dew,' 17.6 per cent. dry matter, and 'dry' grass, 19.0 per cent dry matter. Mitchell and Shepperson (1953) state that a heavy dew can deposit between 1 and 2 tons of moisture on an acre of grass and that this can

best be dried off while the crop is still standing.

Rate of wilting.

A considerable amount of information is available from different countries on rate of moisture fall occurring during wilting but there is little corresponding information on meteorological conditions prevailing at the time of the experiments. As a result it is not possible to tabulate and to compare accurately the results of moisture drops occurring during different types of weather, e.g. very good, good, poor and very poor. It appears that no investigators have used the index of saturation deficiency (a combination of air temperature and percentage relative humidity) as a method of expressing the drying power of the air.

Amos and Woodman (1922) were amongst the first to determine the rate of moisture fall in wilting herbage. After 24 hours wilting in 'dull but fine weather' the moisture content of vetches and oats fell from 76.5 per cent. to 64.3 per cent. i.e. an overall drop of 12.2 per cent. units, or 0.5 units per hour. It is probable that little wilting would have occurred overnight. Working with a crop of juar (sorghum vulgare) Annett and Aiyer (1926) obtained a

moisture drop of 6.5 per cent. units after 12 hours wilting during 'good weather.' Greenhill (1936) quotes a preliminary experiment by Watson at Jeallott's Hill which showed that 6 hours wilting of freshly cut grass during 'fine calm weather' reduced the moisture content from 81 per cent. to 74 per cent. a drop of 7 per cent. units or 1 per cent. unit per hour. Greenhill goes on to describe experiments of his own, involving high-protein grass 8 inches high and wilted over periods of 6, 9, 24, 30, 48 and 54 hours. During the period of the test 'no rain fell and a moderate-strong drying wind prevailed.' Weather conditions were said to be conducive to drying. The results showed that moisture content fell from 73.7 per cent. to 64.3 per cent. in swathes after 24 hours wilting i.e. a drop of 9.4 per cent. units. This was followed by a further drop of 15.9 per cent. units, to 48.4 per cent., after an additional 24 hours. Thus there was an average hourly drop of 0.5 per cent. units over the whole period, including hours of darkness. The rate of wilting was less rapid in windrows, each of which consisted of four swathes. Greenhill also measured the moisture contents in different portions of swathe and found that wide differences occurred, increasing with length of wilting time. After 54 hours the moisture

contents in the top and bottom of a swathe were 40.7 per cent. and 55.9 per cent. respectively.

During 'sunny weather with no rain' Fagan and Ashton (1938) in Wales found that the moisture content of low-protein grass dropped from 78 per cent. to 57 per cent. after 24 hours i.e. an overall unit drop of 21 per cent units, or nearly 2 per cent. units per hour. After an additional 24 hours, during similar weather conditions, the moisture content dropped to 37 per cent. In later experiments, carried out under 'variable weather conditions', there was an average moisture drop of 12 per cent. units during 24 hours, from 80 per cent. to 68 per cent. i.e. a drop of 0.5 units per hour. But in America Woodward (1944), at Beltsville maintained that on a 'good drying day' only 2 hours is required to bring the moisture content down to the 60 per cent. level, and Dobie (1949) in California also claimed rapid rates of wilting in many green crops, from about 75 per cent down to 50 per cent., and sometimes to 40 per cent., during one day. Likewise Crasemann and Heinzl (1949) in Switzerland obtained a rapid rate of wilting, from 81.0 per cent to 68.6 per cent moisture in young grass after only 2 hours i.e. 6 per cent. units per hour. In Scotland Waite and Sastry (1949), experimenting with leafy

ryegrass-timothy mixture, also obtained a rapid reduction in moisture content amounting to 5 per cent. units per hour during 'good weather conditions'. Here, however, the rapid fall in moisture content will undoubtedly have been largely due to the fact that the herbage was turned every 2 hours. During poorer conditions, 'cold and semi-cloudy', the moisture drop was only about 0.5 per cent. units per hour. Hellberg (1945) in Sweden, Krogh (1949-50) in Denmark, Buysse, Martin and Reyntens (1952) and Martin and Buysse (1953) in Belgium have all experimented with wilted and fresh lucerne and found moisture drops varying between 0.3 and 1.5 per cent. units per hour over 24 hour wilting periods. In the Netherlands Dijkstra and Brandsma (1955) have tried wilting for much longer periods, using high-protein spring and autumn grass during three consecutive seasons. Some of the results showed that after 4 days during favourable weather the moisture drop amounted to 41 per cent. units i.e. about 0.5 per cent units per hour, but that 8 days of very unfavourable conditions gave a fall of only 18 per cent. units.

Returning to experimental work conducted in Britain, Mitchell and Shepperson (1953) in Bedfordshire found that whereas grass-clover herbage cut at 11 a.m. with a moisture content of 75 per

cent. wilted to 60 per cent. by 9 p.m., herbage cut at 3 p.m. with 78 per cent. moisture only wilted to 74 per cent. by nightfall. It was concluded that cutting should commence as soon as surface moisture has dried off, since grass cut before noon has a faster initial drying rate and gains a lead, which is often maintained, compared to grass cut later in the day. Mitchell and Shepperson (1955) found that an untouched swathe will act as a thatch and resist water penetration to some extent in light showers but that heavy rain will soak the swathe, whatever its condition and hence prolong drying time.

Watson (1952) in his review states that the speed of desiccation will markedly affect the feeding value of the final product. In the experiments of Mitchell and Shepperson, mentioned above, the effect of mechanical treatment on rate of wilting was tested. The results showed the value of crushing, though it was found that the crushed material absorbed more water at night and was liable to severe damage by rain. Some experiments with a bruising machine, however, Anon (1949-51) indicated that even with a thin swathe bruising was not sufficiently severe with the type of machine employed. Holmes (1954) in Ayrshire also experimented with a bruising machine. In one trial the moisture content of bruised leafy

grass fell by as much as 23.5 per cent. units, from 78.5 per cent. to 55.0 per cent. during a wilting period of 4 hours whereas during the same period the corresponding moisture drop in mown material was only 11.5 per cent. units, from 79 per cent. to 67.5 per cent. Holmes found that during wet weather the herbage reabsorbed moisture at the same rate whether bruised or unbruised. Insufficient results were obtained to show whether or not rain affected the feeding value of the bruised herbage.

If all the foregoing results are considered it is clear that rate of wilting can vary greatly and that this will be due to numerous factors, chief of which are type of weather and type and physical state of the crop. It seems that in Britain and on the Continent a moisture drop of about 2 per cent. units per hour can often be obtained though in parts of America rate of wilting may be much greater.

Overnight wilting.

No mention has been made of changes in moisture content overnight. In Britain it is generally an accepted fact that little or no wilting takes place during the hours of darkness. Murdoch (1953) at Reading has shown this to be the case. In Germany, however, Speer (1950) actually recommended cutting the crop during the evening

rather than during the day, and leaving it to lie overnight when wilting is not too severe.

Crop weight.

That a small fall in percentage of moisture causes a large reduction in the quantity of moisture held by the crop and, therefore, in the weight of the crop, has been amply demonstrated by various workers particularly by those investigating artificial drying which has been found less costly with herbage of reduced moisture content. The content of moisture is usually expressed as the 'water ratio'. There is no need to labour this point but one or two examples are worth mentioning. Greenhill (1936) pointed out that the comparatively small reduction of percentage moisture from 80 per cent. (water ratio 4.0) to 67 per cent. (water ratio 2.0) doubles the output of dry matter per unit of water evaporated. Fagan and Ashton (1938) found that grass containing 80 per cent. water lost 20 per cent. of this after 24 hours of wilting and that after 48 hours it had lost over 40 per cent. Mitchell and Shepperson (1953) calculated that grass herbage cut at a moisture content of 75 per cent. and wilted to 60 per cent. during 10 hours lost 1½ tons of water for every ton of dry matter, or 3 cwt. water per hour. Kervina (1955) tested various silage crops in Jugoslavia and found that wilting for 3 to 6 hours

during 'hot sunny weather' caused a loss in crop weight of between 40 and 44 per cent., while Studer (1955) in Switzerland showed that the weight of green fodder can be reduced by about 50 per cent. in one day during 'sunny weather', from 80-90 per cent. down to 65-70 per cent. moisture.

WILTING IN PRACTICE.

Filling the trench.

Many farm experiments have been carried out on wilting for silage using tower silos, but there is little helpful published information on methods applicable to conditions of silage-making in Britain where the trench silo is widely employed. Shepherd (1952) is the only known investigator to have given practical instructions though, it is almost certain that he refers to the ensilage of chopped rather than long material. Shepherd states that in the first place the moisture content should not fall below 60 per cent. At the end of the wilting period the stalks and leaves should appear distinctly wilted and limp. The herbage should feel cool to the touch but should show no free moisture when twisted, rubbed or compressed by the hand. Ensilage should commence with a layer of slightly wilted material, 2 to 3 ft. in the bottom of the trench, which helps to prevent development of high butyric acid

content in silage and avoid odour. The layer should not be consolidated and no more material should be ensiled until the wilted material has warmed up to 100°F., but not over 120°F. When the desired temperature has been reached the first layer should be thoroughly consolidated. Filling should then continue. If the forage is immature filling should continue with slightly wilted herbage except for the top foot or two. Ensilage should then be completed rapidly and thorough consolidation given throughout the operation. If filling is delayed by 1 or 2 days because of rain the silage will heat up and make further slow filling unnecessary.

Control of wilting time.

Although Shepperson maintains that moisture contents should not fall below 60 per cent. he does not mention how overwilting could be avoided in practice.

Whisler and Frushour (1953) have observed, however, that under farm conditions it was impossible to control the wilting time accurately enough to prevent ensiling at least some material that was well below 70 per cent. moisture content.

Costs.

Economic aspects of the field work have been rarely reported on, though Studer (1955) in Switzerland calculated that the costs for labour

and machinery for silage-making were about 10 per cent. less for wilted than for fresh herbage.

MOISTURE CONTENTS OF WILTED AND FRESH SILAGE

Wet silage.

Most workers agree that high butyric acid contents and large nutrient losses are likely to occur when very succulent crops are ensiled. Results of silage investigations, involving analyses of large numbers of silages, by Watson (1939a) in England, Perkins et al (1945) in America, Axelsson (1951) in Sweden, Brown (1950) in Northern Ireland, Collins and Copeman (1952) in England and Smith (1954) in Scotland serve to emphasise the fact that large quantities of silage are produced from low dry matter materials, that in general these are the poorest silages and that the best silages are usually produced at a moisture content of less than 80 per cent.

Dry silage.

Due to the varying conditions of each experiment diverse opinions exist as to the optimum moisture level required for production of a well preserved wilted silage. The type and physical state of the crop, weather conditions, type of silo, speed of filling, amount of consolidation and kind and quantity of seal used for covering the silage all determine the final conclusion drawn from an experiment.

Thus Samarani (1922) in Italy recommended wilting to the low moisture content of 35 to 40 per cent., ensiling rapidly in air-tight silos and weighting the top heavily. Mihin, Fokin and Tupikova (1936) in Russia found that moisture contents not higher than 50 to 55 per cent. were desirable if good results were to be obtained, but pointed out that gas-tight silos were essential. Dijkstra (1952) claimed good results with moisture contents of 50 per cent. to 60 per cent. though he used small upright silos each of which was filled and sealed in one day to prevent over-heating. Nevens and Kuhlman (1936) maintained that a moisture content of about 60 per cent. was the lower limit for successful ensilage and Kristensen and Tind-Christensen, quoted by Steensberg (1952), agreed that 60 per cent. was the best level. On the other hand Swanson and Tague (1917), Camburn et al (1938) Woodward (1944), Hellberg (1944), Shepherd (1948) and Smith and Davis (1952) all stated that the best moisture content for wilted silage lies between 60 and 70 per cent. Camburn and his co-workers showed that moisture contents above 70 per cent. favoured putrefactive fermentation while below 60 per cent. the herbage was difficult to compress and became easily heated and spoiled. Schieblich (1931) maintained that a moisture content of 65 per cent.

was optimal and that a perfect silage could not be made when the moisture content was about 80 per cent. without addition of sugar. Ellenberger (1937) agreed with Schieblich, Bohstedt (1949) and Axelsson and Kivimäe (1954) recommended a moisture content of 65 to 70 per cent, Breirem (1949), 60 to 75 per cent. and Woodman and Amos (1926), Penzhorn (1931-2), and Burkey and Kroulik (1953) between 65 and 75 per cent. The last named state that above or below these moisture levels is likely to be disadvantageous to production of high quality silage.

Some workers recommend higher moisture levels. For example Kirsch and Schmidt (1955) stated that it should never fall below 70 per cent. while Eriksson (1945) recommended wilting down to 70 to 73 per cent. Henning (1949-50) advised a moisture content of 75 per cent. Modderman (1954) found that best results were obtained at levels between 73 and 76 per cent. moisture. Hopkins and Ripley (1944) worked out a whole range of optimum moisture contents for different crops, some of which required wilting.

QUALITY, DIGESTIBILITY AND LOSSES OF WILTED SILAGE

It is clear from the foregoing that there is wide agreement on the importance of moisture content for successful preservation of the silage. Watson (1952) in his review, however, points out

that one of the main difficulties is to assess the true effect of moisture level on silage quality since much of the material ensiled is cut at a relatively advanced stage when fermentable carbohydrates are present in considerable amounts.

Bacterial fermentation.

That fermentation of silage is slowed down when wilted material has been preserved is clear from a number of investigations. Thus Hastings, Fred and Paterson (1924) have tested Samarani's method of making silage and found that reduction of water prevented bacterial growth. Bender et al (1936) carried out bacterial analyses of experimental silages and found that in a high moisture silage (66.8 per cent. moisture) there was a count of 1,200,000/gram whereas in low moisture silage (44.4 per cent. moisture) the count was only 30,000/gram. Stone et al (1944) found that rate of fermentation and total bacterial count were roughly proportional to the amount of moisture present. Lactobacilli were predominant in all silages though in those containing below 60 per cent. yeasts were common. Mihin, Fokin and Tupikova (1936, 1936a) maintained that a low moisture content of 50 per cent. to 55 per cent. controlled undesirable fermentation due to direct contact of carbon dioxide with the microflora. Wilted material did not compress easily and carbon

dioxide gas could infiltrate, whereas in fresh silage the spaces were filled with water containing carbon dioxide. In later experiments Mihin (1940) changed his conclusions and stated that the weakened fermentation was due to the inability of many bacteria, particularly the butyric and proteolytic types, to attack the cells which possessed a much higher osmotic pressure after than before wilting. Kapelle and Postma (1952) found that the activity of butyric acid bacteria was reduced when the moisture content was lowered and Burkey and Kroulik (1953) that low moisture content tended to retard acid producing bacteria whilst permitting the continued activity of coliform and various other bacteria. Likewise Stirling (1951) and Keddie (1954) showed that wilting caused a delay in bacterial multiplication and Rosenberger (1952) that proteolytic anaerobes were reduced in wilted silage.

pH value.

Results of a large number of analyses have indicated that pH value is usually higher in wilted than in fresh silage. Berezovskii (1940), Mihin (1940), Stone et al (1944), Shepherd et al (1948), Keddie (1954), Nordfeldt (1955), Axelsson and Kivimäe (1955), Kervina (1955), Stopher and Lewis (1955) and Murdoch et al (1955a), to quote a few, have all found higher pH values in wilted

silage. The fact that some investigators have not found significant increases e.g. Autrey, Knodt and Williams (1947), Crasemann and Heinzl (1949) Martin, Stoddard and Porter (1952) and Eriksson (1953) merely emphasises the fact that pH value is not a good guide to the quality of wilted silage, this being the opinion of various workers including Martin and Buysse (1952) and Ulvesli, Fyri veiv and Breirem (1954). It is widely agreed that the occurrence of high pH values does not mean that silage has been poorly preserved as in the case of fresh silage. Buysse, Martin and Reyntens (1952) hold the opinion that a good index of quality in wilted silage is butyric acid content and protein break-down.

Some investigators have found that there is a relationship between pH value and level of dry matter content. Thus Axelsson (1951) in some experiments found that there was a tendency for the pH to rise after a dry matter content of 35 per cent. had been reached. Kapelle and Postma (1952) found the same and pointed out that the optimum pH value for wilted silage may be higher than the optimum value of 4.0 to 4.5 usually quoted for normal silages which have a dry matter content varying from 15 to 25 per cent. Gordon et al (1951) on the other hand obtained different results, a low pH value (4.3) at a dry matter content of

36 per cent. and a higher pH value (4.7) only when the material was half dry at 54 per cent. dry matter.

Organic acids.

Due to the reduced fermentation the contents of lactic, acetic and butyric acids in wilted silage are usually different from those in unwilted material.

Butyric acid.

It is generally agreed that wilting causes a reduction in butyric acid content of silage. Crasemann and Heinzl (1949), experimenting with young grass, found that the content of butyric acid was reduced from 0.18 per cent to 0.0 per cent. in silages containing moisture contents of 85.2 per cent. and 68.6 per cent. respectively. Martin, Stoddard and Porter (1952) working with lucerne cut at the 1/10th bloom stage found that butyric acid was present in the unwilted silages but not in the wilted products. Ulvesli, Fyrileiv and Breirem (1954) on the other hand state that even though wilting has a beneficial affect on quality, some samples of wilted silage have been found to contain as much as 0.96 per cent. butyric acid. In experiments on lucerne, and also on grass, Kervina (1955) obtained falls in butyric acid content of from 0.28 to 0.06 per cent. and from 0.2 to 0.07 per cent. respectively. Low contents of the

acid were also found in wilted silages made from crimson clover, red clover and a mixture of oats and vetches. Murdoch et al (1955a) working with lucerne-timothy mixture, Stopher and Lewis (1955) with whole sugar beet tops, Dijkstra and Brandsma (1955) with grass, and Orth and Hacker (1955) with meadow crops, and many other investigators previously mentioned, have all found that wilting causes a lowering of butyric acid content.

Lactic acid.

The quantity of lactic acid produced in wilted silage is often greater than that in unwilted silage. Hellberg (1945) has made silages from lucerne and estimated lactic acid contents of materials ranging in moisture content of from 83 per cent. to 76 per cent. moisture. The results showed that the content of acid increased with decreasing content of moisture. Eriksson (1953) also made silages from lucerne, at 76 per cent. and 69 per cent. moisture, and with one exception obtained the highest lactic acid contents in the wilted materials. Similar results were obtained for various crops by Brouwer (1931), Ruschman (1940), Haendler (1952), Flieg (1952) and Steensberg (1952), and also by others already mentioned. Sutter (1955) has stressed that slight wilting causes earlier than normal production of lactic acid. Murdoch et al (1955a) found that a

marked increase of this acid only occurred when the wilted material had been chopped. Mihin (1940) is one of the few to have stated that wilting causes a reduced lactic acid fermentation.

Acetic acid.

The results for acetic acid are variable. Crasemann and Heinzl (1949) and Buysse, Martin and Reyntens (1952) found higher contents of acetic acid in wilted than in fresh silage while Martin, Porter and Stoddard (1951), Eriksson (1953) Nordfeldt (1955) and Murdoch et al (1955a) obtained opposite results. Mihin (1940) found both increases and decreases. Kervina (1955) showed that acetic acid content decreased in wilted grass silage but increased in wilted lucerne silage while Axelsson and Kivimäe (1955) found no difference in acetic acid content of fresh and wilted clover silage.

Protein break-down.

Protein break-down occurs in all types of silage. Watson (1939b) states that 'the degree of proteolysis is very variable and cannot be used by itself as a guide to the quality of the silage since the nature of the break-down products is also of supreme importance. The break-down normally proceeds via intermediate, relatively complex compounds to amino-acids. These, since they come from the original "true" protein, may

be regarded as compounds in a reversible reaction, being built up again in the animal. The break-down need not stop at this stage, but may proceed to the ultimate stage, the production of ammonia and other volatile bases.

As regards wilted silage many workers have found protein break-down to be less severe than in fresh silages, though Swanson and Tague (1917) showed that wilted lucerne silage with a moisture content of 60 per cent. to 70 per cent. contained more amino-nitrogen than did the fresh silage. Amos and Woodman (1922) showed that in fresh vetch and oat silage more than 50 per cent of true protein was transferred into "amides" whereas in wilted silage the breakdown amounted to only 30 per cent in wilted silage. Similarly Mihin (1940) obtained less protein break-down and ammonia formation in various wilted silages. Shepherd et al (1948) pointed out, that protein break-down products occur in small amounts in wilted silage and that any ammonia would be utilized by the animal, a point agreed upon by Accardi et al (1954). Kappelle and Postma (1952) analysed 156 samples of silage made from wilted grass and concluded that ammonia fractions declined continuously over the moisture range of 78 per cent. to 50 per cent. Ulvesli, Fyrileiv and Breirem (1954) obtained a lower content of

ammonia-nitrogen in wilted grass silage containing 75.7 per cent. moisture than in fresh silage containing 81.9 per cent. moisture, though reverse results were obtained when the high and low moisture silages were made respectively from wilted crushed and fresh crushed material. Dijkstra and Brandsma (1955) found that the ammonia content of grass silage.containing a moisture content of 72.8 per cent. was very high compared with wilted silages, and Murdoch et al (1955b) working with lucerne-timothy mixture obtained the lowest content of volatile bases in the wilted products.

Temperature and digestibility

At one time farmers were advised to produce silage at a high temperature since it was found that undesirable fermentations were less likely to occur when the material was allowed to become hot. For example, Bunger (1932) recommended temperatures of 140 to 149°F. (60 to 65°C.) and Fry, quoted by Watson (1949), temperatures of 125 to 150°F. (52 to 66°C.).

It is now well known that overheating causes a lowering in digestibility, particularly of the protein fraction, which in severe cases may become almost wholly indigestible. Overheating is, of course, more likely to occur in wilted than in fresh silage and hence it is entirely agreed that

thorough consolidation is a vital factor in successful preservation of wilted material. The temperature is particularly difficult to control in large silos, sometimes even with chopped material. For example Bender et al (1936) who ensiled chopped lucerne, in a tower silo, at 44.4 per cent. and 66.8 per cent. moisture found that the low moisture silage was badly overheated and had reached a maximum temperature of 160°F. (71°C.) whereas the high moisture material produced good silage which had not risen above 122°F. (50°C.). Thermocouples were used to record the temperatures. In contrast, Shepherd and Woodward (1938) who also used a tower silo and chopped lucerne with a moisture content of 44 per cent., found no difficulty in controlling the temperature which reached a maximum of 109°F. (43°C.) at a depth of 6 feet from the top of the silo. Camburn et al (1938), experimenting with lucerne and timothy, were not so successful. They found that overheating occurred at moisture contents below 60 per cent. Gordon et al (1951) were successful with material at a moisture content of 46 per cent. but here gas-tight silos were employed. Orth and Hacker (1955) ensiled meadow grass in tower silos fitted with pressure lids and found that lower digestible coefficients occurred in the

low moisture silage (50 to 55 per cent.) than in the high moisture silage (64 per cent.). Kirsch and Schmidt (1955) advocated chopping of grass and clover herbage because overheating and depression of protein digestibility would occur at a moisture content of less than 70 per cent. Bailey, Balch and Murdoch (1955) examined lucerne-timothy ensiled in 20 ton upright silos. With the aid of thermocouples they recorded an average temperature of 127°F. (53°C.) in herbage of 62 to 65 per cent. moisture whereas in three fresh silages the average temperatures were only 113°F. (45°C.), 118°F. (48°C.) and 103°F. (39°C.) The protein digestibility was reduced in the wilted silage, values for both crude and true protein being about 10 per cent lower than those for any of the other silages, both differences being highly significant. Griffiths (1954) and Stopher and Lewis (1955) have also used thermocouples. In one experiment unchopped wilted sugar beet tops, ensiled in upright silos of 10 to 15 ton capacity, gave temperatures of about 160°F. (71°C.) The moisture content of the wilted tops was 83.0 per cent. The fresh tops contained a moisture content of 86.3 per cent. and the temperature did not exceed 120°F. (49°C.). These results were confirmed in another experiment, and are particularly interesting for it is not easy to understand

why such a relatively small drop in moisture content should cause such a marked rise in temperature in the 'wilted' material.

Losses

Effluent.

In fresh silage effluent seepage usually accounts for some 5 per cent. of the total dry matter ensiled though in wet silage the loss may exceed 10 per cent. The actual quantity of effluent lost will depend on numerous factors chief of which are the moisture content of the crop and weight of seal covering the silage.

That effluent seepage can be prevented by pre-wilting is not surprising, for as already noted, a relatively small drop in per cent. units of moisture will entail a large loss of water. Many years ago Hofer (1929) showed that the quantity of cell sap flowing from a silo was dependent on the dry matter content of the ensiled grass. Perkins and Pratt (1951) experimented with a silo which could similate conditions such as pressure existing at various levels. They found that while there was a heavy loss of effluent from crops with moisture contents of 82 to 86 per cent., even at low applied pressures, there was no seepage from materials containing moisture contents of 68 per cent. or less even when the pressures applied were higher than those prevailing in farm

silos. Buysse, Martin and Reyntens (1952) found that effluent seepage from chopped lucerne was eliminated at a moisture content of 63 to 64 per cent., though Axelsson (1952) mentions figures of 72 to 78 per cent.which closely agrees with experimental results of Sutter (1955) and Murdoch (1954).

Mould and waste.

In addition to the risk of overheating there is also the risk of moulding and spoiling in wilted silage. Amos and Woodman (1922) found that vetches and oats, wilted to 62 per cent. to 65 per cent. moisture and chopped and ensiled in small upright silos, tended to mould. Bender et al (1936) obtained badly moulded silage in a tower silo filled with chopped lucerne containing a moisture content of 44.4 per cent. No mould was present in the fresh silage which contained 66.8 per cent. moisture. On the other hand, Shepherd and Woodward (1938) found no mould in wilted silage produced under the same conditions of crop, moisture content and type of silo. Stone et al (1944) observed that yeasts were commonly present at moisture contents below 60 per cent. Martin, Stoddard and Porter (1952) have ensiled wilted chopped lucerne, in small upright silos, at 60-65 per cent. and 45-54 per cent. moisture and found that the percentage of

spoiled silage was 10.5 per cent. in the high moisture material and 25.2 per cent. in the low moisture material. Martin and Buysse (1953) also found greater amounts of mould in wilted than in fresh lucerne, especially in the unchopped material, while Kirsch and Schmidt (1955) and Nordfeldt (1955) agree that chopping will prevent mould formation in wilted grass and clover. Murdoch et al (1955b) used 20 ton silos and found that silage made from unchopped lucerne and timothy containing 53.9 per cent. moisture, was almost completely mouldy whereas there was no mould in silage with a moisture content of 65.8 per cent.

Fermentation.

It is abundantly clear that accurate determination of the unavoidable or 'invisible' losses occurring during fermentation is a most difficult procedure, irrespective of the kind of silage examined. Extremely variable results have been obtained ranging from 5 per cent. to 50 per cent. loss of dry matter. To obtain a reasonably accurate figure for loss of dry matter in a particular type of silage it is necessary to calculate the average of a number of results. As will be seen shortly this has been carried out for wilted silage.

The marked variation in individual results

AVERAGE LOSSES IN WILTED SILAGE COMPARED WITH THE AVERAGE LOSSES IN FRESH SILAGE

Authors	Type of Silo	Crop	Number of Tests	WILTED SILAGE							FRESH SILAGE.						
				Composition **		Losses					Composition **		Losses				
				Moisture Content %	Dry Matter %	Dry Matter %	Crude Protein %	N-free Extractives. %	Crude Fibre %	Carotene %	Moisture Content %	Dry Matter %	Dry Matter %	Crude Protein %	N-free Extractives. %	Crude Fibre %	Carotene %
Krogh (1949-50)	E	lucerne	3	80.3	19.7	8.8	7.4	-	-	-	87.4	12.6	7.1	14.6	-	-	-
Stopher & Lewis (1955)	T	sugar beet tops	1	79.3	20.7	40.9	35.8	-	-	-	83.4	16.6	40.8	32.4	-	-	-
Axelsson & Kivimäe (1955)	E	clover	3	74.0	26.0	7.1	8.4	12.0	-	-	85.3	14.7	14.0	7.1	20.2	-	-
Hellberg (1945)	E	lucerne	2	72.2	27.8	4.0	7.4	-	1.4	-	82.9	17.1	9.2	12.0	-	7.8	-
Kristensen *	E	grass	1	71.2	28.8	14.6	-	-	-	-	79.1	20.9	20.4	-	-	-	-
Crasemann & Heinzl (1949)	E	grass	1	68.6	31.4	3.3	-	-	-	-	82.4	17.6	14.4	-	-	-	-
Annett & Aiyer (1926)	P	juar (sorghum vulgare)	1	67.9	32.1	11.7	-	-	-	-	74.4	25.6	8.9	-	-	-	-
Eriksson (1953)	E	lucerne	4	66.1	33.9	5.1	2.7	7.4	3.1	38.3	81.5	18.5	14.1	12.9	21.2	3.6	31.6
Nordfeldt (1955)	E	grass	1 †	65.0	35.0	4.5//	-	-	-	-	79.0	21.0	10.0//	-	-	-	-
Amos & Woodman (1922)	E	vetches & oats	1	64.3	35.7	8.7	-	-	-	-	76.5	23.5	13.3	-	-	-	-
Tind Christensen	E	grass	4	61.7	38.3	7.3	-	-	-	-	80.8	19.2	23.1	-	-	-	-
Murdoch et al (1955b)	E	lucerne & timothy	3	58.4	41.6	17.2	7.1	26.1	11.5	98.8	76.5	23.5	27.5	16.3	43.1	9.7	42.6
Steensberg (1942)	T	lucerne	1	54.0	46.0	29.9	-	-	-	-	84.0	16.0	23.4	-	-	-	-
Shepherd et al (1948)	T	lucerne-grass	1	45.0	55.0	8.3	2.8	-	-	38.3	70.6	29.4	10.3	4.8	-	-	22.2
			26	Grand average: 13.4							Grand average: 16.6						

** either of the crop or of the silage.
* quoted by Steensberg (1942)
† average of an unknown number of results.
average of 3 tests.
// organic matter.

E = Experimental.
T = tower.
P = pit.

for loss of dry matter will be due to the fact that (a) the dry matter content of both herbage and silage is only about one-third to one-fifth of the total amount of green material employed (b) accurate sampling is not easily carried out, particularly with wilted materials (c) few investigators employ the same size and type of silo (d) different crops are ensiled at different stages of growth (e) some crops are ensiled chopped and some in an unchopped state (f) some crops are ensiled with preservative and some with no addition (g) different amounts of consolidation and covering materials are applied and (h) corrections are not always made for loss of volatile constituents in the laboratory oven.

The table on page 43 shows results for dry matter and nutrient losses in a number of wilted and fresh silages. Some of the silages received treatments additional to wilting but this information is not given. With the exception of Steensberg (1942) all the investigators named in the table have already been mentioned in preceeding sections. It will be noticed that results for the wilted silages have been tabulated in descending order of moisture content, starting from a slightly wilted silage containing 80.3 per cent. moisture (see Krogh) and finishing with a half dry silage

containing a moisture content of only 45 per cent. (see Shepherd). The moisture content of the corresponding fresh silages vary from 87.4 per cent., (see Krogh) to 70.6 per cent. (see Shepherd et al).

The figures for dry matter losses are very variable, particularly for the wilted materials, from as low as 3.3 per cent. (see Crasemann and Heinzl) to as high as 40.9 per cent. (see Stopher and Lewis). Examination of the results of Krogh and Stopher and Lewis shows little difference in dry matter losses of the wilted and fresh silages, 8.8 per cent. and 7.1 per cent., and 40.9 per cent. and 40.8 per cent. respectively. The explanation is that the 'wilted' silages were high in moisture content and should really be classed as wet silage. With the exception of two instances (Annett and Aiyer and Steensberg) the remaining results show less dry matter loss for the wilted than for the fresh products. In some instances wilting caused much less loss of dry matter (e.g. Axelsson and Kivimäe). Considering the results as a whole the table shows an average dry matter loss of 13.4 per cent. for the wilted silages and a corresponding average loss of 16.6 per cent. for the fresh silages, so that the dry matter loss is approximately 20 per cent. lower in the wilted than in the fresh materials. That total losses are normally reduced as a result of wilting has been

amply confirmed by other investigators, e.g. Mihin (1940) Buysse, Martin and Reyntens (1952) and Dijkstra and Brandsma (1955).

Less information is available on the losses of individual constituents. Crude protein losses appear to be lower in wilted silage, though in two instances the loss is about the same as in fresh silage, (Stopher and Lewis and Axelsson and Kivimäe). The three results for N-free extractives show less loss for the wilted materials though, as would be expected, carotene losses are greater in these silages.

Few results are available on losses of digestible and true nutrients though it seems that here too the advantage lies in favour of the wilted product. Dijkstra and Brandsma (1955) found an average loss of 24 per cent. digestible crude protein in wilted grass silages containing 50 per cent. moisture but a loss of as much as 60 per cent. in silage containing 72.8 per cent. moisture while Murdoch and others (1955b) obtained a loss of 31.9 per cent. true protein in the wilted silage referred to in the table, and only 54.4 per cent. in the fresh silage.

TREATMENTS ADDITIONAL TO WILTING.

In many experiments on wilted silage investigators have given additional treatments, prior to ensilage, in the form of chopping and/or addition of preservative.

Wilting and mechanical treatments.

It is generally agreed that wilted material should be given some kind of mechanical treatment, usually chopping, since wilted herbage is much more easily consolidated when ensiled in a finely divided condition. Breirem (1949), Anderson and Haraldson (1951), Jarl (1951), Martin and Buysse (1953) and Kirsch and Schmidt (1955), to quote a few, all agree that wilted materials should be chopped. It is interesting to note, however, that Murdoch et al (1955a) found lacerated silage to have no advantage over chopped silage.

Wilting and preservative treatments

There is little doubt that wilted silage will be slightly better preserved when preservative has been added. Swanson and Tague (1917) found that the total number of good silages made from lucerne was not quite as high when no additions of molasses or cornmeal had been given. Schieblich (1930) stated that the addition of 1 per cent. can sugar or lactose compensated the bad effect of too high a moisture content. Newlander, Ellenberger and Jones (1937) showed that timothy

and lucerne could be ensiled successfully with or without molasses when the moisture content was 65 to 70 per cent. though addition of molasses materially aided in preventing putrefaction in high moisture silage. It was thought probable that under ordinary farm conditions use of molasses would be a good insurance policy. In contrast De Ruyter de Wildt (1939) showed that silage made from wilted grass without the addition of sugar was equal in quality to silage made from the same grass without wilting and with addition of rather more than 1 per cent. sugar. Krogh (1949-50) found that fermentation losses in lucerne silage were least with the highest of three rates of formic acid treatment. Shepherd et al (1948) maintained that preservatives had the least value with low- or medium- protein crops and also with crops of low moisture content and that often the preservative does little more than make the silage more palatable. Shepherd considered that less preservative is required when a crop is wilted because at that moisture level the fermentation process has slowed down. This conclusion was also arrived at by Crasemann and Heinzl (1949). Axelsson and Kivimäe (1954) ensiled wilted material with and without Kofa salts, a mixture of calcium formate and sodium nitrite,

and found that while wilting alone reduced dry matter losses from 9.7 to 4.2 per cent., wilting and Kofa salts reduced the losses still further from 4.2 to 1.8 per cent. However, Axelsson and Kivimäe (1955) considered that when the moisture content of crops ranged between 60 per cent. and 70 per cent. the use of preservatives appeared to give too slight an effect to make the addition economical.

Wilting + mechanical + preservative treatments.

Sometimes all three treatments are given. In practice, however, the farmer would require special silage machinery to perform the work efficiently. Steensberg (1952) is one of a number of investigators who holds the opinion that additives are unnecessary when the crop has been both wilted and chopped.

THE FEEDING OF HIGH AND LOW DRY MATTER SILAGES.

The amount of investigational work carried out on the feeding of high and low moisture silages is small compared to experiments on quality and losses of silage. The information at present available, however, does show the disadvantage of feeding 'wet' rather than 'dry' silage to the ruminant. Watson (1939c) points out that dry matter is probably the most important determination where a knowledge of the feeding value of the silage is concerned. 'Since silage is a watery

food, minor variations in moisture content may make appreciable differences in the actual feeding. The average moisture content of silage is in the neighbourhood of 75 per cent. but this may easily vary up to 80 per cent. in the same silo, thus reducing the actual percentage of dry matter from 25 to 20 which represents one-fifth less dry matter in the sample. A ration of 40 lb. of silage of the lower moisture content would have to be increased to 50 lb. at the 80 per cent. level if the dry matter intake is to remain constant.' Hamilton (1952) states that the importance of high protein has been over emphasised in the past and the significance of dry matter overlooked. He says that 'while 80 lb. good quality silage with only 15 per cent. dry matter provides only enough starch equivalent for maintenance, a similar quantity with a dry matter of 25 per cent. supplies enough starch equivalent for nearly 2 gallons of milk.'

Discussing the advantages of wilting Murdoch (1953) emphasises the fact that an animal can only eat a limited quantity of food and that the wetter the silage the smaller will be the total intake of nutrients. Jarl (1952) puts this in a different way by stating that any process such as wilting which concentrates the nutritive value will obviously increase the general value of the

roughage.

Dairy cattle.

Cooper (1954) and Dempster (1954), as well as many others, maintain that silage extracted from different levels of a silo will have a marked effect on milk yield. Cooper found that when cows received silage containing a moisture content of 82 per cent. from the top of the silo, milk production fell, but rose gradually as the lower levels of the silo were reached where moisture content was only 76 per cent. When the cows received the high moisture silage the cows ate approximately the same weight of silage as when the dry matter was higher. It was concluded that palatability and possibly certain physical attributes of the silage were of more importance than the dry matter content in controlling intake of wet silage. Variations of moisture content within the silo can of course be overcome by adjusting the method of cutting out the silage in such a way that each cow receives some silage from the top and some from the bottom of the silo, but this is a tedious process for farm workers. (Farming News 1954).

Morrison (1955) considers that it is simply not worthwhile making young lush grass into silage and advises making it from a more mature crop, and so obtain a high dry matter yield. Morrison

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maintains that it is better to feed a dairy cow silage of 14-15 per cent. crude protein in a dry matter content of 22-23 per cent., rather than feed silage of 18-20 per cent. crude protein in a dry matter content of 17-18 per cent.

Before the 2nd World War experiments were already in progress to determine the effect of silage of variable moisture content on dairy cows. Nevens (1933) found that high moisture maize silage so restricted intake that milk yields suffered. Vezzani and Carbone (1937) found that while silage of moderate moisture content produced no changes in liveweight of cows high moisture silage caused loss of weight. Woodward and Shepherd (1942) made a statistical study of silages containing different moisture contents and found that the amount of dry matter consumed by cows was greater with low moisture silages (45 per cent.) than with high moisture silages (70 per cent.). Gordon et al (1951a) reported an interesting experiment which entailed feeding 14 milking cows to appetite with half-dry silage containing a moisture content of 46 per cent. and a slightly wilted silage containing 64 per cent. moisture. Daily consumption of silage per 100 lb. of liveweight was 2.52 lb. and 2.34 lb. respectively for the 'low' and 'high' moisture materials. With 'high' moisture silage there was an average

Liveweight daily loss of 0.43 lb. and a 30-day decline in milk production of 11.4 per cent., but with the 'low' moisture silage there was an average daily gain in liveweight of 0.30 lb. and a decline in milk production of only 8.0 per cent. For each 100 lb. of 4-per cent. corrected milk produced, 101.3 and 108.2 lb. dry matter were consumed from the 'high' and 'low' moisture silages respectively. Thus, cows fed on low moisture silage consumed more dry matter and maintained body weight better than cows given slightly wilted silage.

Moore (1954) gives some interesting results for dairy cattle fed on various types of fresh and wilted silages. The information is set out in the following table which is self-explanatory.

CROP		SILAGE	
Type	Treatment	Moisture Content %	D.M. eaten per 100 lb. LW/day.
Orchard grass	fresh	79.7	1.36
	wilted	66.9	2.00
orchard grass	fresh	71.8	2.08
	wilted	59.5	2.11
lucerne	fresh	77.9	1.23
	wilted	72.7	1.94
	wilted	65.6	2.34
	half-dry	45.7	2.52
soybeans	fresh	74.1	1.52
	wilted	58.1	1.85

Fattening cattle and sheep.

Interesting work has recently been carried out by Dodsworth and Campbell (1952, 1953, 1954) on the effect of dry matter percentage of silage on the dry matter intake and performance of fattening cattle and sheep. All the silages were made from unwilted materials. An important conclusion drawn was that when succulents form the sole or major part of the diet for ruminants then the dry matter content of the diet should never fall below some critical point, possibly between 20 and 25 per cent. (80 and 75 per cent. moisture) if satisfactory daily dry matter intake and hence, satisfactory performance are to be obtained. Rogers and Bell (1953) have found that the dry matter intake of sheep fed on standard silage, partly replaced by silage of below 60 per cent. moisture content, is greatly increased but that this does not affect consumption of hay.

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SECTION 2

FIELD TRIALS

WILTING TRIALS USING LONG GRASS-CLOVER HERBAGE.

During 1953 and 1954 a total of eight wilting trials were carried out on the farms of the Edinburgh School of Agriculture. Of the total eight trials five were conducted during mid- to late-May and three during early- to mid-June. The trials were carried out in a field of grass and clover which had been sown down in 1951 with a complex seeds mixture for subsequent grazing and silage. At the ordinary 'medium protein' silage stage the crop was estimated to yield between 5 and 6 tons per acre.

High protein herbage, containing 17-22 per cent. crude protein in the dry matter was used for three trials and medium to high protein material of 15-16 per cent. crude protein for a further three trials. Of the remaining two trials one was carried out with medium protein herbage of 12 per cent. crude protein and the other with herbage of 10 per cent. crude protein in the dry matter.

Each trial consisted of two parts which for convenience have been termed long period wilting and short period wilting. The 'long' trials entailed wilting periods of 18, 21 and 24 hours and the corresponding periods for the 'short' trials were 3, 6 and 9 hours. (Compared to some practices on the Continent moderate periods of wilting were, therefore, here given in all instances). Data on the crop, times of cutting

and times of wilting for each pair of long and short trials are given in appendix 1.

Meteorological conditions.

Except in one instance during 1954, when a prolonged wet period occurred, all trials were carried out regardless of official weather forecasts and irrespective of local weather conditions on the days chosen for the work. The results do not, therefore, relate solely to good weathers but to all types of weather; good, moderate and poor. Weather conditions for previous years were studied and appropriate data are given in appendix 2 along with comparative figures for eastern areas of north, mid- and south England. The appendix shows that average conditions in S.E. Scotland, as typified by the Edinburgh values, for the principal ensiling months of May, June and July are:- rainfall, 1.9 - 2.7 inches; sunshine, 5.3 - 6.4 hours; daily maximum air temperature, 55 - 65°F.; relative humidity at 1 p.m., 68 - 71 per cent.; and number of rain days,* 14 - 15.

During the trials information on rainfall, sunshine and temperature were obtained from the nearby Boghall meteorological sub-station and these figures along with values for relative humidity and saturation deficiency are also given in appendix 2. Unfortunately no anemometer was available so that accurate data on wind speeds were not obtainable. Wind speeds and cloud amounts were estimated but

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* reasonable

records of these are not shown in the appendix.

Saturation deficiency was used as the index for expressing the drying power of the air, rather than relative humidity, since the former is based on both air temperature and relative humidity. Saturation deficit values were calculated from a graph,* using the Boghall records for air temperature and relative humidity. Two examples of diurnal variation of saturation deficiency, selected at random from these records, are shown in the graph on page 67 and the figures used for constructing these curves are given in appendix 3. The graph indicates that the drying power of the air is greatest between mid-morning and mid- to late-afternoon but that it is very low during the night. For these trials, therefore, it was decided to disregard any wilting which might occur overnight.

Although saturation deficiency is a satisfactory index for comparing wilting trials it does not take into account the effect of wind. It is known, however, that a positive linear relationship exists between wind speed and rate of drying under any given degree of saturation deficiency so that unexpected moisture contents occurring in the results may be attributed to the effect of wind.

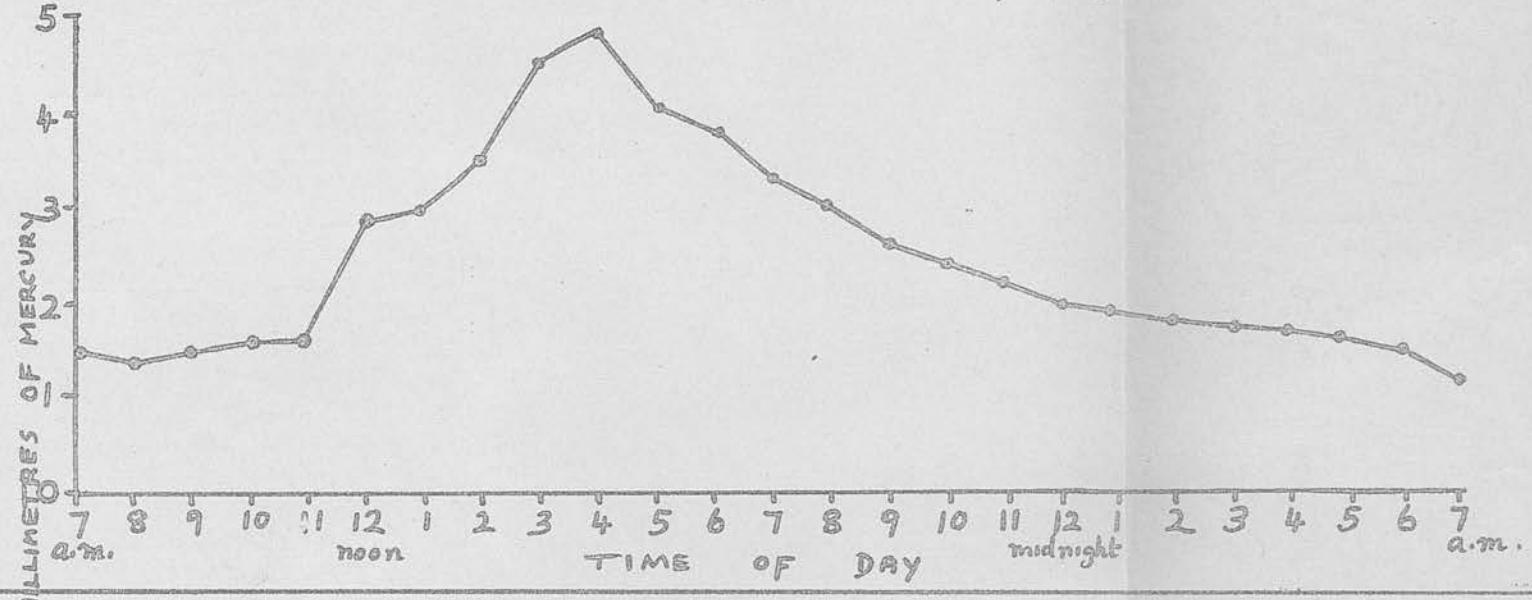
Design of trials.

In both seasons the field trials were designed

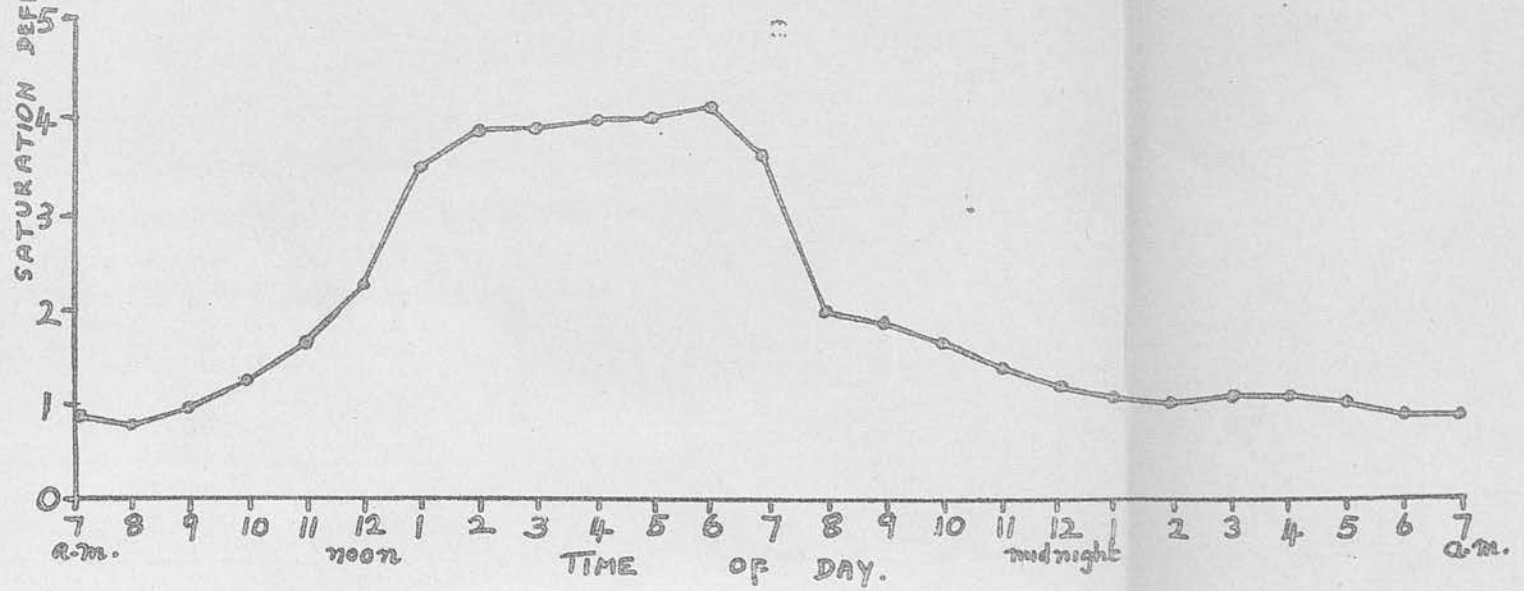
* graph by P.A. Buxton Bulletin of Entomological Research Sept. 1931 22 (3) 431-447.

DIURNAL VARIATION OF SATURATION DEFICIENCY

30th - 31st JULY 1954



18th - 19th SEPTEMBER 1954.



in the form of a simple block layout. Diagrams, given in appendix 4, show that in 1953 five blocks were used containing sufficient randomised square yard plots for seven wilting trials, each plot being replicated five times. As already mentioned, however, only five trials were conducted during 1953. The blocks, each measuring 28 yds. x 1 yd., were laid out in one line across the field to give a total length of 140 yards. The 1954 block design was similar except that the five blocks contained less plots and were laid out as two adjacent strips, each 50 yards in length. In both seasons half the plots were allocated for the long wilting trials and half for the short wilting trials. Each plot was divided into four sub-plots, F, A, B and C and these were randomised for the following treatments:

LONG PERIOD WILTING		SHORT PERIOD WILTING	
Sub-Plots	Treatment	Sub-Plots	Treatment
F	0 hours wilting	F	0 hours wilting
A	18 " "	A	3 " "
B	21 " "	B	6 " "
C	24 " "	C	9 " "

The experimental plots were separated one from another by square yard discard plots. Immediately prior to commencing a trial the discard plots were cut with a scythe and the herbage removed to one

side, an operation which took between ten and fifteen minutes. Thus the herbage in the experimental plots, cut shortly afterwards, was exposed to wind and sun as occurs in practice when a crop is mown. During any one main trial ten experimental plots were cut, five for long wilting and five for short wilting giving a total of forty sub-plot samples for moisture determinations. The time taken to cut five experimental plots, for short or for long wilting trials, and to lay down the sub-plot materials A, B and C for wilting in the form of small swathe sections, was half an hour. Great care was taken in simulating proper swathes. A time-table was adhered to and where necessary slight alterations made to the times of sample collection.

The experimental plots were cut with hand shears rather than with the scythe in order to avoid disturbing the herbage. In 1953 each sub-plot herbage was cut and treated as a separate entity but in 1954, with the object of reducing sampling errors, each sub-plot sample was obtained by removing small amounts of herbage from the entire square yard plot.

All the F samples were collected immediately after cutting. With the long trials cutting was always performed at 3.30 p.m., the wilted materials A, B and C being collected the following day at

9.30 a.m., 12.30 p.m., and 3.30 p.m., i.e. after 18, 21 and 24 hours respectively. The short trial plots were always cut the day following that of the long trial plots. With four of the short trials cutting was performed at 6.30 a.m. The wilted materials, together with those of the long wilt trials were collected at 9.30 a.m., 12.30 p.m., and 3.30 p.m., i.e. after 3, 6 and 9 hours exposure. With the remaining four short trials cutting was performed at 10.30 a.m., and collecting times were also at three hour intervals, at 1.30 p.m., 4.30 p.m. and 7.30 p.m.

Each fresh or wilted sample was placed into a 4 lb. biscuit tin immediately on collection. In the first trials the entire contents of each sub-plot was used for the sample but when crop yield later increased it was necessary to discard the excess herbage. The time taken to collect, transport and weigh a total of forty samples for one trial usually amounted to one and a half hours. No loss in fresh weight occurred during such periods. In order to save time and oven space the samples were not transferred to proper drying trays but were left in the biscuit tins, each of which possessed a few small holes to facilitate drying. An 'EVENHEAT' MITCHELL GRAHAM electric oven was employed and drying was carried out at 100°C.

The dried replicate samples from the 1953

trials were bulked for chemical analysis. Figures for crude protein and crude fibre contents are given in appendix 5. Crude protein contents in the dry matter varied from 24.3 to 9.7 per cent. and the corresponding crude fibre values ranged from 18.2 to 32.1 per cent. Examination of the appendix shows that there was no apparent change in the percentage of these constituents attributable to wilting. With the 1954 samples no analyses were carried out other than that for crude protein in the fresh materials. These results are also given in appendix 5.

The results show that many of the unwilted samples were very low in dry matter content. Even with the later trials, when stage of growth had increased, the highest dry matter content in unwilted material was only 18.7 per cent. The mean dry matter content for the total fifty samples of unwilted herbage collected during the 1953 trials was only 16.1 per cent. while the corresponding figure for thirty fresh samples collected in 1954 was as low as 14.3 per cent. Thus, on examining the following results the reader should bear in mind that in most instances wilting commenced with very succulent herbage of high moisture content.

Individual results.

Results for moisture contents, rates of

moisture drop, sample weights and relative increases in dry matter are given in appendices 6, 7, 8 and 9. Summarised results, extracted from appendices 6 and 7 are included in the following notes on each trial. Wilting curves are shown in the graphs on pages 80 and 91 which, except for the first two trials, also show corresponding curves for saturation deficiency.

1953 WILTING TRIALS

WILTING TRIAL 1

TABLE 1. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE - 1953.
(each result is a mean of five replicates)

Sub-Plots	Crop Treatment	Moisture Content %
LONG PERIOD WILTING		
F	Freshly cut on 14th May - 3.30 p.m.	84.3
A	Collected on 15th May after 18 hr. exposure - 9.30 a.m.	86.2
B	" " " " after 21 hr. exposure - 12.30 p.m.	80.5
C	" " " " after 24 hr. exposure - 3.30 p.m.	77.7
F - C = an overall drop of 6.6 per cent. units of moisture		
SHORT PERIOD WILTING		
F	Freshly cut on 15th May - 6.30 a.m.	87.3
A	Collected on 15th May after 3 hr. exposure - 9.30 a.m.	83.8
B	" " " " after 6 hr. exposure - 12.30 p.m.	80.2
C	" " " " after 9 hr. exposure - 3.30 p.m.	78.1
F - C = an overall drop of 9.2 per cent. units of moisture		

Long period wilting

Cutting was performed at 3.30 p.m. on 14th May. The herbage was leafy, 11 inches high and wet with rain which had fallen earlier in the day. During the afternoon the air was moist and the sky overcast. Rain fell overnight but ceased at 7 a.m. the following morning giving a total rainfall of 1.7 m.m. since the previous morning. The weather improved during the 15th morning and for the remainder of the day there was a light breeze with eight-tenths cumulus. Slight drizzle fell during the afternoon. Weather conditions over the whole trial were classed as poor.

Table 1 shows that the effect of overnight rain was still noticeable in the A sub-plot swathes at 9.30 a.m., the average moisture content of the composite sample being 86.2 per cent. By 12.30 p.m. the figure had fallen to 80.5 per cent. and to 77.7 per cent. by 3.30 p.m. giving an overall moisture drop of 6.6 per cent. units. Thus during 24 hours the dry matter had risen from 15.7 to 22.3 per cent. The increase in dry matter percentage was equivalent to an increase of approximately 42 per cent. of dry matter in the wilted herbage.

Short period wilting.

The herbage was very wet when cut at 6.30 a.m. on 15th May, the moisture content being 87.3 per cent. Weather conditions were classed as moderately

good. After 6 hours and 9 hours of wilting the moisture contents had fallen to similar levels as those in the corresponding long wilt swathes, the figures being 80.2 and 78.1 per cent. at 12.30 p.m. and 3.30 p.m. respectively. There was an overall moisture drop of 9.2 per cent. units at the end of 9 hours. The dry matter content rose from 12.7 to 21.9 per cent. so that the wilted herbage contained 72 per cent. more dry matter than did the original fresh herbage.

WILTING TRIAL 2

TABLE 2. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE - 1953.

(each result is a mean of five replicates)

Sub-Plots	Crop Treatment	Moisture Content %
LONG PERIOD WILTING		
F	Freshly cut on 21st May - 3.30 p.m.	84.6
A	Collected on 22nd May after 18 hr.exposure - 9.30 a.m.	82.7
B	" " " " after 21 hr.exposure - 12.30 p.m.	79.8
C	" " " " after 24 hr.exposure - 3.30 p.m.	74.0
F - C = an overall drop of 10.6 per cent. units of moisture		
SHORT PERIOD WILTING		
F	Freshly cut on 22nd May - 6.30 a.m.	86.1
A	Collected on 22nd May after 3 hr.exposure - 9.30 a.m.	87.3
B	" " " " after 6 hr.exposure - 12.30 p.m.	83.8
C	" " " " after 9 hr.exposure - 3.30 p.m.	75.9
F - C = an overall drop of 10.2 per cent. units of moisture		

Long period wilting.

The crop was now 12-15 inches high. Flowering heads of ryegrass and cocksfoot were just visible. The herbage was wet with rain when cut on the afternoon of 21st May, the moisture content being 84.6 per cent. At the time of cutting there was a light breeze and fair weather cumulus with sunny periods. Early the following morning it was noticed that the swathes which had lain overnight were covered with dew. There was little wind and the sky was overcast with nimbostratus. At 7 a.m. rain began to fall though this soon ceased. By 9 a.m. a strong breeze had sprung up and the sky had begun to clear. For the rest of the day there were sunny periods with eight-tenths cumulus. Slight drizzle fell at 12.30 p.m. Weather conditions over the whole trial were classed as moderately good.

By 12.30 p.m. the moisture content of the B swathes had fallen to 79.8 per cent. After a further period of three hours the moisture contents had reached 74 per cent. giving an overall drop of 10.6 per cent. units during 24 hours exposure. There was a corresponding increase in dry matter content of from 15.4 to 26.0 per cent., equivalent to an increase of 69 per cent. in the amount of dry matter over that contained in the original herbage.

Short period wilting.

Weather conditions were moderately good.

The crop was wet with dew when cut, moisture content being 86.1 per cent. The effect of the early morning rain which occurred after cutting was still noticeable at 9.30 a.m. in the A swathes, the moisture content then being 87.3 per cent. During the following three hours the moisture drop was similar to that in the long wilt plots over the same period. By 3.30 p.m. there was a marked decline to 75.9 per cent. giving a total drop of 10.2 per cent. units. This was similar to the overall drop for the long wilt plots. The dry matter content rose from 13.9 to 24.1 per cent., equivalent to an increase of 73 per cent. in the quantity of dry matter over that contained in the fresh material.

WILTING TRIAL 3

TABLE 3. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE - 1953.

(each result is a mean of five replicates)

LONG PERIOD WILTING		
Sub-Plots	Crop Treatment	Moisture Content. %
F	Freshly cut on 28th May - 3.30 p.m.	83.9
A	Collected on 29th May after 18 hr. exposure - 9.30 a.m.	76.6
B	" " " " after 21 hr. exposure - 12.30 p.m.	72.7
C	" " " " after 24 hr. exposure - 3.30 p.m.	70.1
F - C = an overall drop of 13.8 per cent. units of moisture		

WILTING TRIAL 3. (cont.)

SHORT PERIOD WILTING		
Sub-Plots	Crop Treatment	Moisture Content. %
F	Freshly cut on 29th May - 6.30 a.m.	85.3
A	Collected on 29th May after 3 hr. exposure - 9.30 a.m.	81.8
B	" " " " after 6 hr. exposure - 12.30 p.m.	75.9
C	" " " " after 9 hr. exposure - 3.30 p.m.	69.8
F - C = an overall drop of 15.5 per cent. units of moisture		

Long period wilting.

The herbage was 18 to 20 inches high and at the heading stage when cut at 3.30 p.m. on 28th May. At this time drying conditions were good, as shown by the high saturation deficit value of 5.1 in the graph on page 80. The moisture content of the freshly cut herbage was 83.9 per cent. Slight drizzle occurred for a short time after cutting and early the following morning there was further precipitation, though this soon ceased. By 7.15 a.m. the cloud had begun to disperse and drying conditions rapidly improved as indicated by the curve for saturation deficiency. By 9 am. the sun was shining and there was a wind. The weather remained fine for the rest of the day and, taking the trial as a whole, weather conditions were very good. The moisture content of the A swathes had already

fallen to 76.6 per cent. by 9.30 a.m. even though the tops of the swathes were still covered with rain droplets. Thereafter there was a steady fall in moisture content, the final figure being 70.1 per cent, in the C swathes at 3.30 p.m. The overall moisture drop after twenty-four hours exposure was 13.8 per cent. units. During the same period the dry matter rose from 16.1 to 29.9 per cent., equivalent to an increase of 86 per cent. in the amount of dry matter in the herbage.

Short period wilting.

Weather conditions were very good. The early morning rain on 29th May ceased before the plots were cut at 6.30 a.m., the moisture content of the herbage then being 85.3 per cent. The tops of the A swathes were dry when collected at 9.30 a.m. and it is interesting to note that the average moisture content of these was not as low as that of the corresponding long wilt A swathes which had been lying exposed to drizzle. The graph on page 80, however, shows that the rate of wilting was rather more rapid with the short wilt swathes, the moisture content falling to 75.9 per cent. by 12.30 p.m. and to 69.8 per cent. by 3.30 p.m. This gave an overall drop of 15.5 per cent. units, 2 per cent. units greater than in the long wilt herbage. There was a rise in dry matter content of from 14.7 to 30.2 per cent., this being equivalent to an

increase of 105 per cent. in the quantity of dry matter, compared to that in the fresh material.

WILTING TRIAL 4

TABLE 4. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE - 1953.

(each result is a mean of five replicates)

Sub-Plots	Crop Treatment	Moisture Content %
LONG PERIOD WILTING		
F	Freshly cut on 8th June - 3.30p.m.	81.8
A	Collected on 9th June after 18 hr. exposure - 9.30a.m.	78.4
B	" " " " after 21 hr. exposure - 12.30p.m.	75.3
C	" " " " after 24 hr. exposure - 3.30p.m.	69.0
F - C = an overall drop of 12.8 per cent. units of moisture.		
SHORT PERIOD WILTING		
F	Freshly cut on 9th June 10.30a.m.	82.8
A	Collected on 9th June after 3 hr. exposure - 1.30p.m.	76.2
B	" " " " after 6 hr. exposure - 4.30p.m.	70.9
C	" " " " after 9 hr. exposure - 7.30p.m.	70.2
F - C = an overall drop of 12.6 per cent. units of moisture		

Long period wilting.

The crop had reached a height of 30-33 inches and grass heads were now fully emerged. The plots were dry when cut on the afternoon of 8th June and

WILTING TRIALS 1-4

drying conditions were good as shown by the S.D. value of 4.0 at 2.30 p.m. There was slight wind and no cloud. The following morning the air was saturated as a result of ground mist. The mist was still present at 9.30 a.m. when the wilt A swathes, covered with moisture droplets, were collected. On account of the mist wilting could not have commenced until 10 a.m.

Thereafter the day was fine and cloudless and there was a slight breeze. Weather conditions were, therefore, classed as very good. That drying conditions rapidly improved as soon as the mist had begun to disperse at about 10 a.m. is indicated by the steep rise of the S.D. curve and by the corresponding sharp fall in the curve for moisture content. By 3.30 p.m. the C swathes contained 69.0 per cent. moisture, giving an overall drop of 12.8 per cent. units over the twenty-four hour period of wilting. During the same period dry matter percentages rose from 18.2 to 31.0 per cent., this being equivalent to an increase of 70 per cent. in the quantity of dry matter compared to that in the freshly cut material.

Short period wilting.

Weather conditions were very good. The plots were cut at 10.30 a.m., not at 6.30 a.m. The herbage was damp when cut, moisture content being 82.8 per cent. Rate of wilting was high and by 4.30 p.m. the moisture content had dropped to 70.9

per cent. From 4.30 p.m. to 7.30 p.m. negligible wilting occurred and it will be noticed that during this period there was a corresponding marked fall in the S.D. curve. The overall moisture drop of 12.6 per cent. units after nine hours of wilting was similar to that for the long wilt swathes. The dry matter content rose from 17.2 to 29.8 per cent., an increase of 73 per cent. in the amount of dry matter compared to that contained in the unwilted herbage.

WILTING TRIAL 5

TABLE 5. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE - 1953.

(each result is a mean of five replicates)

Sub-Plots	Crop Treatment	Moisture Content %
LONG PERIOD WILTING		
F	Freshly cut on 11th June 3.30 p.m.	81.3
A	Collected on 12th June after 18 hr. exposure - 9.30 a.m.	76.7
B	" " " " after 21 hr. exposure -12.30 p.m.	73.1
C	" " " " after 24 hr. exposure - 3.30 p.m.	66.8
	F - C = an overall drop of 14.5 per cent. units of moisture	
SHORT PERIOD WILTING		
F	Freshly cut on 12th June 10.30 a.m.	82.2
A	Collected on 12th June after 3 hr. exposure - 1.30 p.m.	77.0
B	" " " " after 6 hr. exposure - 4.30 p.m.	72.7
C	" " " " after 9 hr. exposure - 7.30 p.m.	73.2
	F - C = an overall drop of 9.0 per cent. units of moisture	

Long period wilting.

The crop was now at a stemmy stage of growth and had reached a height of 36 inches. The herbage, damp from previous rain, contained 81.3 per cent. moisture when cut on the afternoon of 11th June. Drying conditions were good, there being a clear sky and strong wind. The following day it was warm and there was extensive cloud and a light wind. Considering the trial as a whole weather conditions were very good. At 9.30 a.m. it was observed that the B swathes had been disturbed - presumably due to the strong wind the previous afternoon. This would explain the large fall in moisture content during the first eighteen hours exposure, i.e. from 81.3 to 76.7 per cent. The overall drop in moisture content during the twenty four hours was 14.5 per cent. units. The dry matter content rose from 18.7 to 32.2 per cent. - equal to an increase of 78 per cent. in amount of dry matter.

Short period wilting.

Weather conditions were classed as moderately good. The plots were cut at 10.30 a.m. and by 4.30 p.m. the moisture content had fallen to 72.7 from 82.2 per cent. The slight increase to 73.2 per cent. moisture, between 4.30 p.m. and 7.30 p.m., could be attributed to a fall of dew in the early evening. The overall moisture drop during 9 hours was 9.0 per cent. units. The dry matter rose

from 17.8 to 26.8 per cent., equivalent to 51 per cent. more dry matter than that in the unwilted herbage.

1954 WILTING TRIALS.

WILTING TRIAL 6

TABLE 6. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE - 1954.
(each result is a mean of five replicates)

Sub-Plots	Crop Treatment	Moisture Content %
LONG PERIOD WILTING		
F	Freshly cut on 19th May - 3.30 p.m.	84.3
A	Collected on 20th May after 18 hr. exposure - 9.30 a.m.	79.5
B	" " " " after 21 hr. exposure -12.30 p.m.	76.8
C	" " " " after 24 hr. exposure - 3.30 p.m.	72.3
F - C = an overall drop of 12.0 per cent. units of moisture		
SHORT PERIOD WILTING		
F	Freshly cut on 20th May - 6.30 a.m.	85.1
A	Collected on 20th May after 3 hr. exposure - 9.30 a.m.	83.9
B	" " " " after 6 hr. exposure -12.30 p.m.	81.3
C	" " " " after 9 hr. exposure - 3.30 p.m.	77.6
F - C = an overall drop of 7.5 per cent. units of moisture		

Long period wilting.

Cutting was performed on the afternoon of 19th May, the herbage being 12 to 15 inches high, leafy and damp at the base. The moisture content was

84.3 per cent. The weather was very dry, there was a moderate breeze and S.D. value rose from 4.8 to 5.7 between 3 p.m. and 4.30 p.m. In the early afternoon the sky was overcast but later it cleared to five-tenths stratocumulus. It remained dry overnight though there was some rain the following morning at 7.a.m. Again the sky was overcast with stratocumulus but there was a moderate breeze and the sky cleared to seven-tenths cumulus after 9.30 a.m. Drying conditions steadily improved, the highest S.D. value recorded being 6.2 at 3 p.m. as shown in the graph on page 91. Weather conditions over the whole trial were classed as moderately good. When collected at 9.30 a.m. the A swathes were still covered with water droplets but table 6 shows that the moisture content was considerably below that of the freshly cut material collected the previous afternoon. By 3.30 p.m. the moisture content of the C swathes was 72.3 per cent. Thus, during twenty-four hours there was an overall moisture drop of 12.0 per cent. units. Dry matter content rose from 15.7 to 27.7 per cent. giving an increase of 76 per cent. in the amount of dry matter compared to that in the original material.

Short period wilting.

The plots were cut at 6.30 a.m. on 20th May. Weather conditions were classed as poor. It will

be noticed that the overall moisture drop of 7.5 per cent. units was considerably less than than of the long wilt materials. The greater drop in the long wilt swathes would probably be due to the very good drying conditions the previous afternoon. The dry matter content of the short wilt swathes rose from 14.9 to 22.4 per cent. over the nine hour period. This was equivalent to an increase of 50 per cent. in the quantity of dry matter present.

WILTING TRIAL 7

TABLE 7. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE - 1954.
(each result is a mean of five replicates)

Sub-Plots	Crop Treatment	Moisture Content %
LONG PERIOD WILTING		
F	Freshly cut on 27th May - 3.30 p.m.	84.9
A	Collected on 28th May after 18 hr. exposure - 9.30 a.m.	87.0
B	" " " " after 21 hr. exposure -12.30 p.m.	85.6
C	" " " " after 24 hr. exposure - 3.30 p.m.	84.2
F - C = an overall drop of 0.7 per cent. units of moisture		
SHORT PERIOD WILTING		
F	Freshly cut on 28th May -10.30 a.m.	87.4
A	Collected on 28th May after 3 hr. exposure - 1.30 p.m.	84.9
B	" " " " after 6 hr. exposure - 4.30 p.m.	84.2
C	" " " " after 9 hr. exposure - 7.30 p.m.	83.0
F - C = an overall drop of 4.4 per cent. units of moisture		

Long period wilting.

The grass heads were partly emerged and crop height was 20 to 24 inches when cutting was performed on the afternoon of 27th May. The moisture content of the fresh herbage was then 84.9 per cent. There was little wind and the sky was overcast with altostratus. Thundery showers, forecast for the night of 27-28th, commenced at 8.30 p.m. On the following morning 6.8 mm. rain was recorded on the rain gauge when the A swathes were collected at 9.30 a.m. As a result of the rain the moisture content of these swathes was 2 per cent. units higher than that of the original herbage. At 9 a.m. the cloud began to clear, though the atmosphere remained damp for the rest of the day. This is shown by the S.D. curve which only reaches a value of 3.8 by 3 p.m. At 4.30 p.m. slight rain fell from stratocumulus cloud. For this trial, weather conditions were classed as very poor.

The C swathes were damp when collected at 3.30 p.m. and as will be noted the moisture content in these was slightly less than that of the herbage c cut on the previous day. Overall moisture drop was only 0.7 per cent. units. The total drop on the 28th day amounted to 2.8 units but most if not all of this drop will have been due to evaporation of surface moisture. The dry matter rose from 15.1

to 15.8 per cent. over the twenty-four hours, this being equivalent to 5 per cent. increase in the amount of dry matter present in the herbage.

Short period wilting.

Weather conditions were classed as poor. When cutting was performed at 10.30 a.m. on 28th May the grass was very wet from overnight rain and moisture content was as high as 87.4 per cent. By 7.30 p.m., after nine hours exposure, it had fallen to 83.0 per cent., so that here, as with the long wilt swathes, it is probable that only surface moisture was removed. The overall moisture drop was 4.4 per cent. units. The dry matter rose from 12.6 to 17.0 per cent., this being equivalent to an increase of 35 per cent. in the amount of dry matter.

WILTING TRIAL 8

TABLE 8 PERCENTAGE MOISTURE CONTENT OF FRESH AND WILTED HERBAGE - WILTING TRIAL 8.

(each result is a mean of five replicates)

Sub-Plots	Crop Treatment	Moisture Content %
LONG PERIOD WILTING		
F	Freshly cut on 10th June - 3.30p.m.	86.7
A	Collected on 11th June after 18 hr. exposure - 9.30a.m.	86.5
B	" " " " after 21 hr. exposure -12.30p.m.	84.9
C	" " " " after 24 hr. exposure - 3.30p.m.	82.1
F - C = an overall drop of 4.6 per cent. units of moisture		
SHORT PERIOD WILTING		
F	Freshly cut on 11th June -10.30a.m.	85.6
A	Collected on 11th June after 3 hr. exposure - 1.30p.m.	83.2
B	" " " " after 6 hr. exposure - 4.30p.m.	80.5
C	" " " " after 9 hr. exposure - 7.30p.m.	77.8
F - C = an overall drop of 7.8 per cent. units of moisture		

Long period wilting

The crop had reached a mature stage, it being in full head and at a height of 30 to 33 inches. Rain had fallen at midday and at 3.30 p.m. the herbage was very wet when cut, 86.7 per cent. moisture. By this time the weather had improved considerably, there being only one-tenth cumulus,

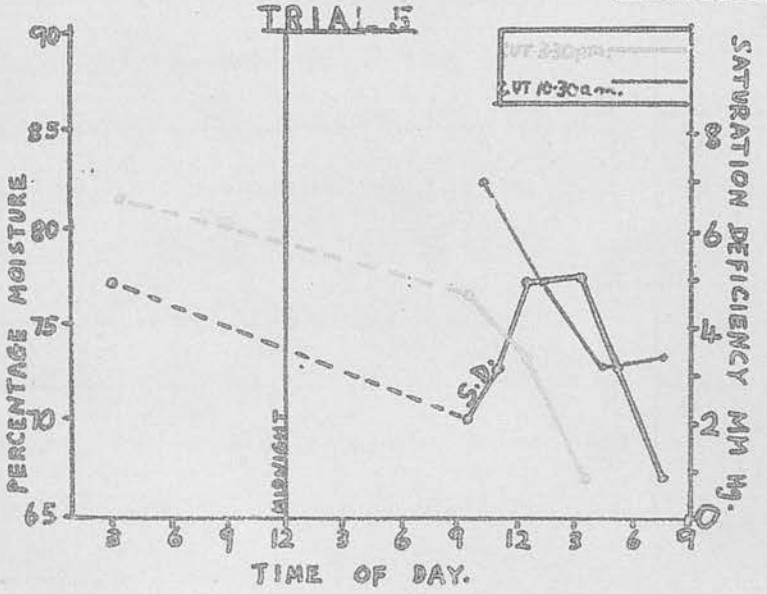
sunshine and a strong breeze. The S.D. value was high, 4.8. But at 4.30 p.m. the sky became overcast with stratocumulus and by 5 p.m. the wind had dropped, the air had become cool and rain had commenced. It continued to rain overnight. At 9.30 a.m. the following morning 4.7 mm. rain was recorded on the rain gauge. For the rest of the day the sky was almost overcast, the air was cool and there was a moderate breeze. Weather conditions for the trial as a whole were classed as poor.

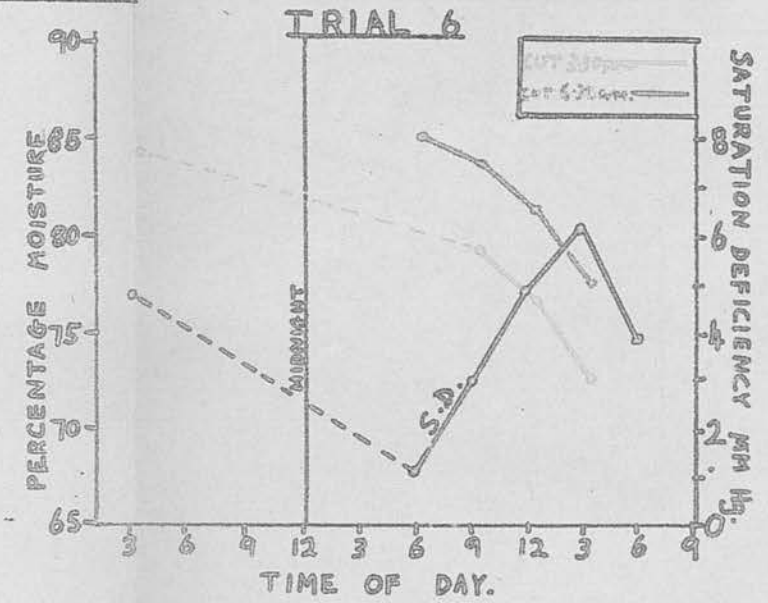
Rain droplets were still adhering to the tops of the A swathes when these were collected at 9.30 a.m. but by now the moisture content had fallen to the same level as that in the fresh herbage cut the previous afternoon. The overall moisture drop was 4.6 per cent. units and most of this loss will have been due to surface evaporation. Dry matter content rose from 13.3 to 17.9 per cent., an increase of 35 per cent. in the amount of dry matter contained in the herbage.

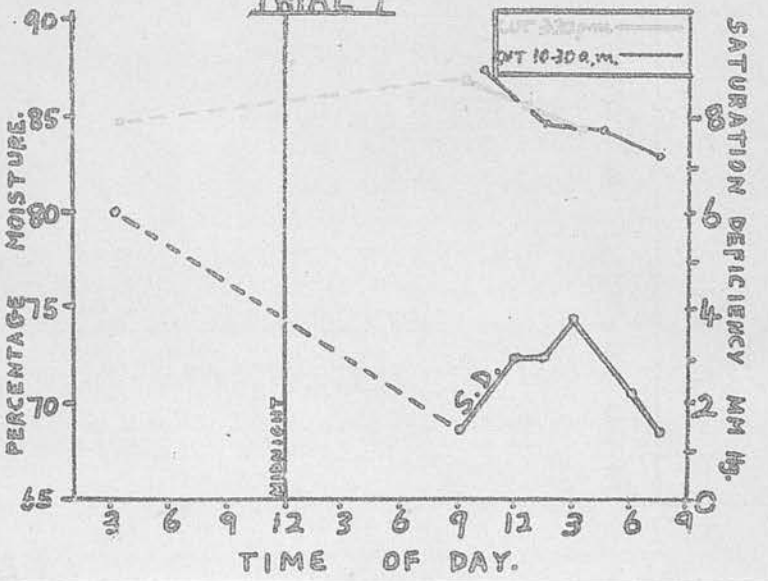
Short period wilting.

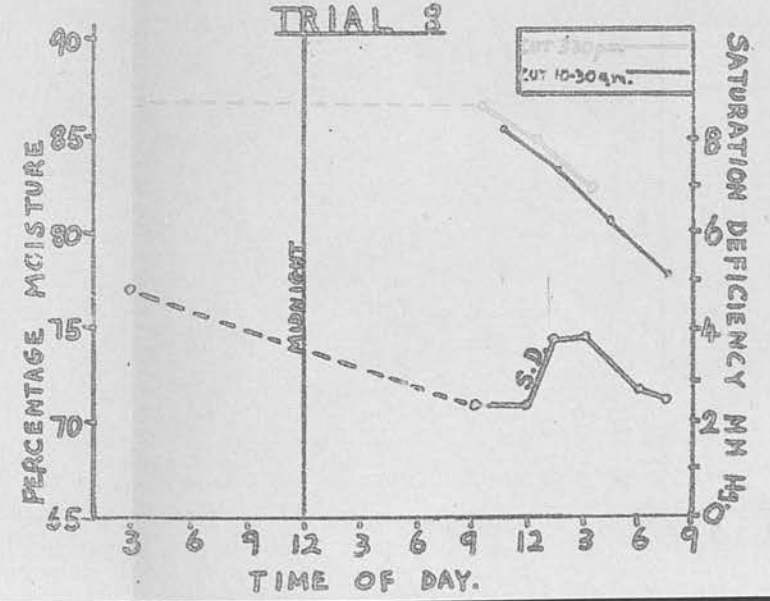
Weather conditions were classed as poor and the herbage was wet when cut at 10.30 a.m. A little wilting occurred during the final three hour period 4.30 p.m. to 7.30 p.m., when weather conditions had improved. As a result the overall moisture drop of 7.8 per cent. units was greater than that of the long wilt swathes. The dry matter rose from 14.4 to 22.2 per cent., this

WILTING TRIALS 5-8









being equivalent to an increase of 54 per cent. in the amount of dry matter present.

Combined results.

The foregoing results have been grouped together in table 9 on page 93. It will be noticed that in 1953 the fresh herbage moisture contents tended to decrease with progress of the trials, from 84.3 to 81.3 per cent. with long wilt trials 1 and 5 and from 87.3 to 82.2 per cent. with the corresponding short wilt trials. These decreases would be due to increases in stage of growth, i.e. reductions in leaf-stem ratio. With the 1954 trials the effect of stage of growth on moisture content was masked by wet weather during trials 7 and 8.

Average figures for wilting in all weather conditions are given in table 10 below and in the graph on page 94.

TABLE 10. PERCENTAGE MOISTURE CONTENTS OF GRASS-CLOVER HERBAGE WILTED UNDER VARIOUS WEATHER CONDITIONS.

(eight 'long' and eight 'short' trials)

LONG PERIOD WILTING			SHORT PERIOD WILTING	
Sub-Plots	Crop Treatment	Moisture Content %	Crop Treatment	Moisture Content %
F	fresh	84.0	fresh	85.2
A	wilted for 18 hours	81.7	wilted for 3 hours	82.3
B	wilted for 21 hours	78.5	wilted for 6 hours	78.7
C	wilted for 24 hours	74.5	wilted for 9 hours	75.7
F - C = overall per cent unit drop of		9.5	overall per cent. unit drop of	9.5

TABLE 9. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE USED FOR WILTING TRIALS 1 - 8.

(each result is a mean of five replicates)

LONG PERIOD WILTING - 1953

Sub-Plots	Crop Treatment	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
F	fresh	84.3	84.6	83.9	81.8	81.3
A	wilted 18 hours	86.2	82.7	76.6	78.4	76.7
B	wilted 21 hours	80.5	79.8	72.7	75.3	73.1
C	wilted 24 hours	77.7	74.0	70.1	69.0	66.8

SHORT PERIOD WILTING - 1953

F	fresh	87.3	86.1	85.3	82.8	82.2
A	wilted 3 hours	83.8	87.3	81.8	76.2	77.0
B	wilted 6 hours	80.2	83.8	75.9	70.9	72.7
C	wilted 9 hours	78.1	75.9	69.8	70.2	73.2

LONG PERIOD WILTING - 1954

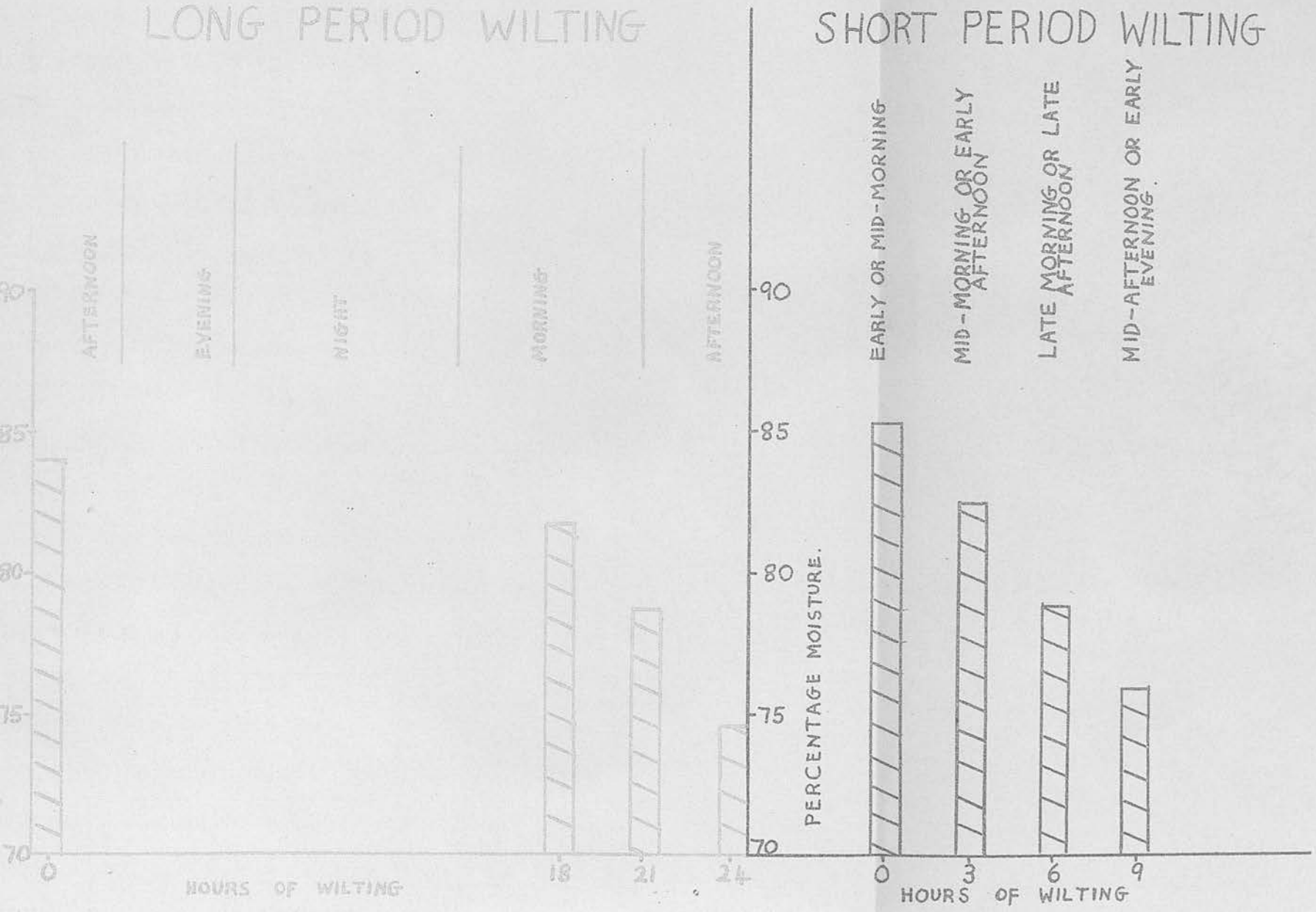
Sub-Plots	Crop Treatment	Trial 6	Trial 7	Trial 8		
F	fresh	84.3	84.9	86.7		
A	wilted 18 hours	79.5	87.0	86.5		
B	wilted 21 hours	76.8	85.6	84.9		
C	wilted 24 hours	72.3	84.2	82.1		

SHORT PERIOD WILTING - 1954

F	fresh	85.1	87.4	85.6		
A	wilted 3 hours	83.9	84.9	83.2		
B	wilted 6 hours	81.3	84.2	80.5		
C	wilted 9 hours	77.6	83.0	77.5		

AVERAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE

1953 AND 1954
ALL WEATHERS.



The high average moisture content of the fresh materials should be noted, i.e. 84.0 and 85.2 per cent. respectively for the long and short trials. The contents of moisture in the wilted swathes were similar for long and short wilting, there being approximately 82 per cent. in the A swathes after 18 or 3 hours wilting, 79 per cent. in the B swathes after 21 or 6 hours and 75 per cent. in the C swathes after 24 or 9 hours wilting. It has been calculated that with the long trials the overall drop in moisture content was the same for both long and short wilting, i.e. 9.5 per cent. units after 24 or 9 hours. With the long trials 2.5 units of this overall drop of 9.5 units occurred in the A swathes, 3.0 units in the B swathes and 4.0 units in the C swathes. With the short wilt swathes the corresponding figures were 3.0, 3.5 and 3.0 per cent. units respectively for the three wilting periods.

Classification of weather.

Since it is of more importance to know the effect of different types of weather on the rate wilting the results have been regrouped under moderate - very good and poor - very poor weather conditions. The results are shown in table 11 and in the graphs on pages 98 and 99. With regard to moderate - very good weather conditions it will be observed that the moisture content of

the freshly cut materials for the long trials, 83.2 per cent., was below that of the corresponding fresh materials for the short trials, 84.7 per cent. This would be due to the standing herbage being drier in the afternoons than in the early mornings. With the long trials moisture content dropped from 83.2 per cent. to 78.8 per cent. in the A swathes after 18 hours exposure, i.e. between mid-afternoon and mid-morning the following day. It was assumed that little if any wilting took place overnight and that this fall of 4.4 per cent. units would have occurred partly during the late afternoon and early evening, and partly during the following morning prior to swathe collection. Almost the same amount of moisture was lost from the short wilt A swathes during only three hours exposure, i.e. 3.5 per cent. units, though the moisture content at the end of the three hour period was higher than that of the corresponding long wilt A swathes. After 21 and 6 hours exposure respectively the moisture contents of the long and short wilt B swathes had reached a similar level, 75-76 per cent., but during a further three hours the rate of wilting was greatest in the long wilt C swathes, the final figure being 70.4 per cent. compared to 73.5 per cent. in the short wilt C swathes. Increases in amounts of dry matter varied from 51 to 105 per

cent. compared to that contained in the freshly cut materials.

TABLE 11. PERCENTAGE MOISTURE CONTENTS OF GRASS-CLOVER HERBAGE WILTED UNDER GOOD AND POOR WEATHER CONDITIONS.

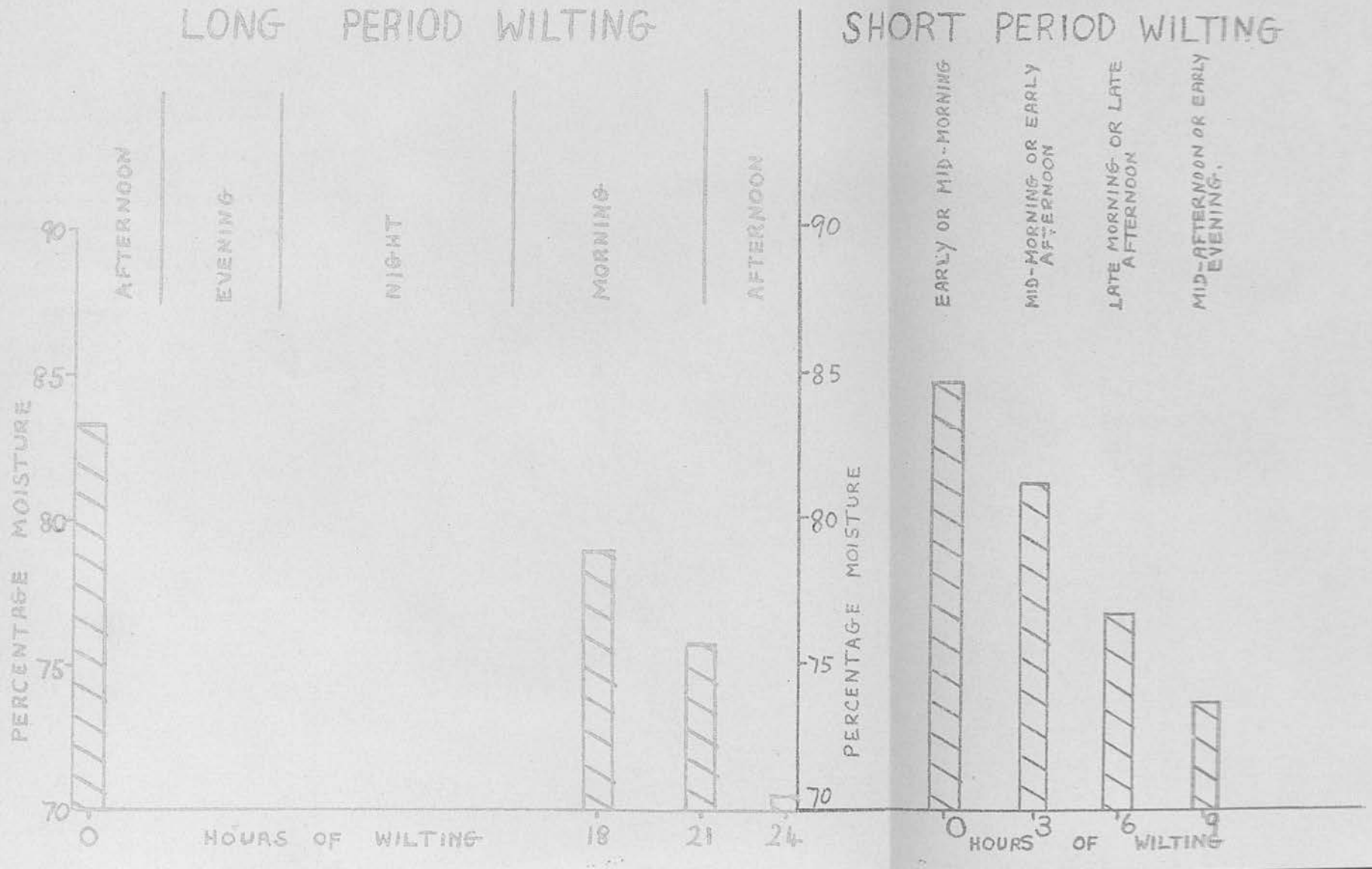
Sub-Plots	Crop Treatment	Moisture Content %	Crop Treatment	Moisture Content %
MODERATE - VERY GOOD WEATHER				
F	fresh	83.2	fresh	84.7
A	wilted for 18 hours	78.8	wilted for 3 hours	81.2
B	wilted for 21 hours	75.6	wilted for 6 hours	76.7
C	wilted for 24 hours	70.4	wilted for 9 hours	73.5
F - C =	overall per cent. unit drop of	12.8	overall per cent. unit drop of	11.2
POOR - VERY POOR WEATHER				
F	fresh	85.3	fresh	86.0
A	wilted for 18 hours	86.5	wilted for 3 hours	84.0
B	wilted for 21 hours	83.7	wilted for 6 hours	82.0
C	wilted for 24 hours	81.3	wilted for 9 hours	79.5
F - C =	overall per cent unit drop of	4.0	overall per cent. unit drop of	6.5

The average overall moisture fall was slightly greater with long than with short wilting, the figures being 12.8 and 11.2 per cent. units respectively. Analysis of the results showed that with the long wilt trials, 4.4 per cent. units of the total unit drop of 12.8 units occurred in the A swathes between 3.30 p.m. and 9.30 a.m. the following morning, 3.2 units in the B. swathes between 9.30 a.m. and 12.30 p.m. and 5.1 units

AVERAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE.

1953 AND 1954.

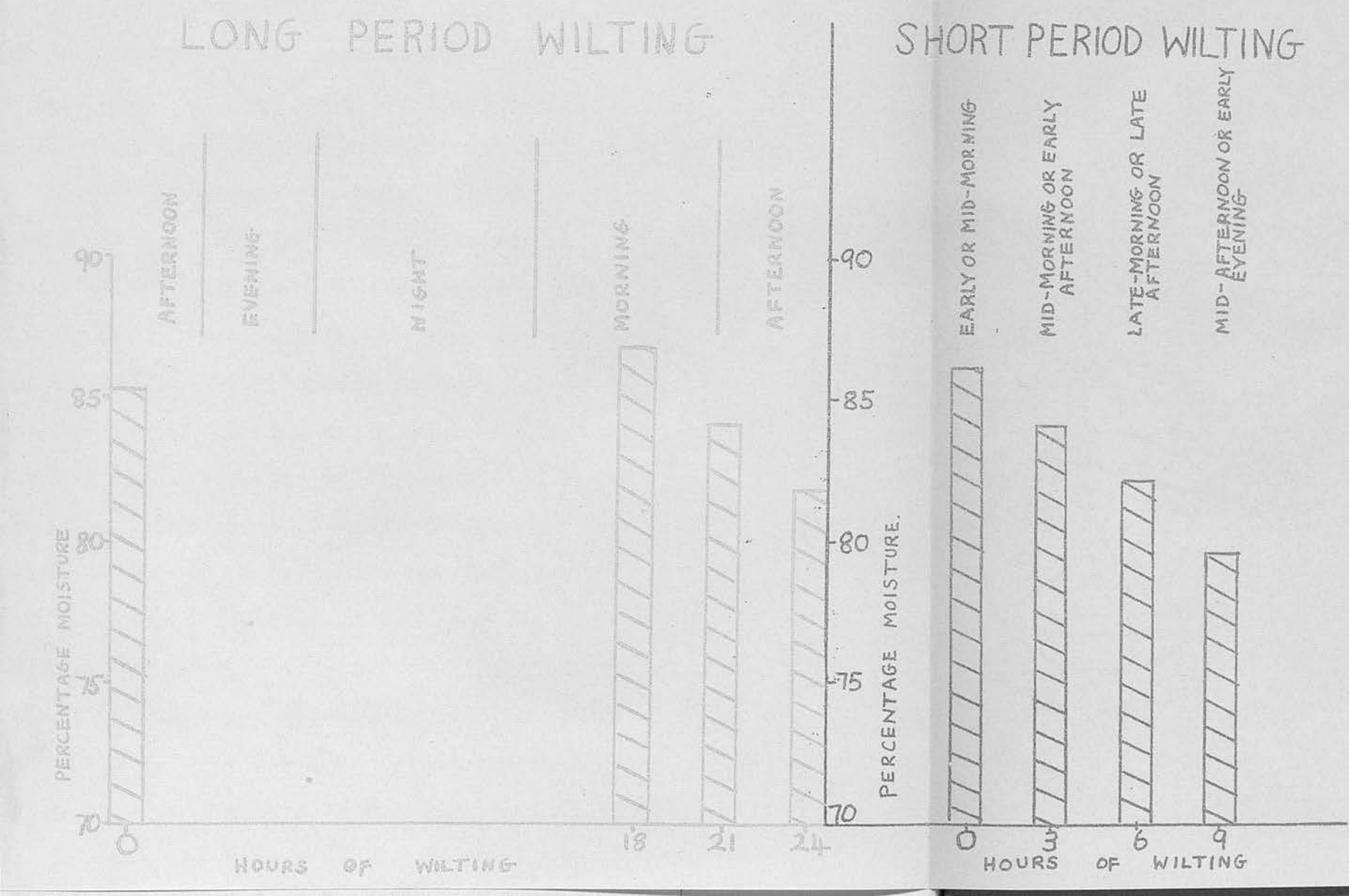
MODERATE - VERY GOOD WEATHER.



AVERAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE

1953 AND 1954

POOR-VERY POOR WEATHER



in the C swathes between 12.30 p.m. and 3.30 p.m. With short period wilting the total drop of 11.2 per cent. units occurred in more equal proportions over the three wilting periods; 3.5, 4.5 and 3.2 units respectively between early or mid-morning and mid-afternoon or early evening.

The results for poor- very poor weather conditions show that the initial moisture contents were very high for both long and short trials, 85.3 and 86.0 per cent. respectively. With the long trials the moisture content increased to 86.5 per cent. in the A swathes during the 18 hour period from mid-afternoon to mid-morning the following day. This would have been due to overnight and/or early morning rain. The amount of drying out and wilting which occurred in this very wet herbage over the following six hours, between the times of collecting the A and C swathes, amounted to 5.2 per cent. units and was similar to the fall which occurred in the short wilt herbage. The overall moisture drop was greater and the final moisture percentage less in the short trials than in the long trials but these differences were small and for both long and short trials it could be said that the 80 per cent. level had been reached. Increases in amounts of dry matter varied from 5 to 54 per cent.

Analysis of the results showed that the overall moisture drop of 4.0 per cent. units for the long trials was apportioned as follows: Between 3.30 p.m. and 9.30 a.m. the following morning there was an increase of 1.3 per cent. units. Thereafter there were decreases of 3.0 units between 9.30 a.m. and 12.30 p.m. and 2.3 units between 12.30 p.m. and 3.30 p.m.

In order to obtain more detailed information on the effect of weather all the results were re-grouped under the following: very good, moderate - good, poor and very poor weather. The term 'very poor' signifies frequent showers or drizzle, not continuous rain. Owing to the small number of trials carried out and hence the limited meteorological records obtained it is impossible exactly to define the above four types of weather. The available meteorological data have, however, been used in an attempt at classification but the weather conditions, set out below, should merely be taken as a guide when these are compared with the corresponding figures for moisture drops shown in table 12.

VERY GOOD WEATHER

Precipitation	-	usually none
Daily sunshine	-	8 hours or more
Daily air temperature	-	between 56°F. and 66°F.
Saturation deficiency	-	a maximum recorded value of 8.3.

MODERATE - GOOD WEATHER

Precipitation	-	very occasional showers
Daily sunshine	-	not exceeding 8 hours
Day air temperature	-	between 55°F. and 60°F.
Saturation deficiency	-	a maximum recorded value of 6.2

POOR WEATHER

Precipitation	-	occasional showers
Daily sunshine	-	not exceeding 4½ hours
Day air temperature	-	between 50°F. and 60°F.
Saturation deficiency	-	a maximum recorded value of 4.8

VERY POOR WEATHER*

Precipitation	-	frequent rain or drizzle
Daily sunshine	-	not exceeding 1 hour
Day air temperature	-	61°F.
Saturation deficiency	-	a maximum recorded value of 3.8

* one trial only.

TABLE 12. VARIATIONS IN PER CENT. MOISTURE DROP IN WILTED GRASS-CLOVER SWATHES RELATIVE TO WEATHER CONDITIONS.

TRIALS:-	L trials 3, 4 & 5 S trials 3 & 4	L trials 2 & 6 S trials 1, 2 & 5	L trials 1 & 8 S trials 6, 7 & 8	L trial 7
Type of Weather	DROP IN PER CENT. UNITS OF MOISTURE			
very good	> 12			
moderate - good		8 - 12		
poor			3 - 8	
very poor				< 3

Table 12 shows that during very good weather conditions the moisture drop exceeded 12 per cent. units. Under moderate - good conditions moisture drops varied between 8 and 12 units, under poor conditions from 3 to 8 units and under very poor weather conditions less than 3 per cent. units. It should be pointed out that this last figure refers to one trial only, though the results of a later trial carried out under similar conditions confirm this one result.

Moisture levels.

It will be recalled that a wet silage is considered as one containing more than 80 per cent.

moisture. Table 13 expresses the wilting results for all weather conditions, in terms of moisture levels. It shows that out of the total sixteen trials with 3 or 18 hours of wilting there were six instances of moisture contents falling to below the 80 per cent. level, but that none of these was below the 75 per cent. level. The remaining ten instances occurred between 80 per cent. and 90 per cent. moisture. Thus with the two shortest periods of wilting there was not one instance of moisture contents reaching 70 per cent. the level at which grass herbage is thought best for ensiling in trench silos. By increasing the periods to 6 and 21 hours the number of instances occurring below the 80 per cent. level was increased to eight. Four of these ranged between 70 and 75 per cent. The best results were obtained with the longest wilting periods, 24 or 9 hours, there being only three instances of moisture contents exceeding the 80 per cent. level. Of the remaining thirteen results five ranged from 70 to 75 per cent. and three from 65 to 70 per cent.

TABLE 13. VARIATIONS IN THE TIME OF WILTING OF GRASS-CLOVER HERBAGE RELATIVE TO PERCENTAGE MOISTURE LEVEL.

MOISTURE LEVEL %	WILTING PERIODS - hours		
	3 and 18 hr.	6 and 21 hr.	9 and 24 hr.
85 - 90	4	1	-
80 - 85	6	7	3
75 - 80	6	4	5
70 - 75	-	4	5
65 - 70	-	-	3
Total Long and Short Trials	16	16	16

The effect of time of cutting.

Average results for wilting under all weather conditions have been compared in relation to the two times of cutting for short wilting, i.e. 6.30 a.m. and 10.30 a.m. Average results for the long wilting trials (table 10) have already been discussed but are repeated here in table 14 for comparative purposes. The graph on page 107 is self-explanatory.

It will be remembered that the four short trials entailing 6.30 a.m. cutting, were carried out on days different from those which required 10.30 a.m. cutting. The two groups are not, therefore, strictly comparable. The greatest overall moisture drop of 10.5 per cent. units. occurred with the materials cut at 6.30 a.m. and left lying until 3.30 p.m., even though their

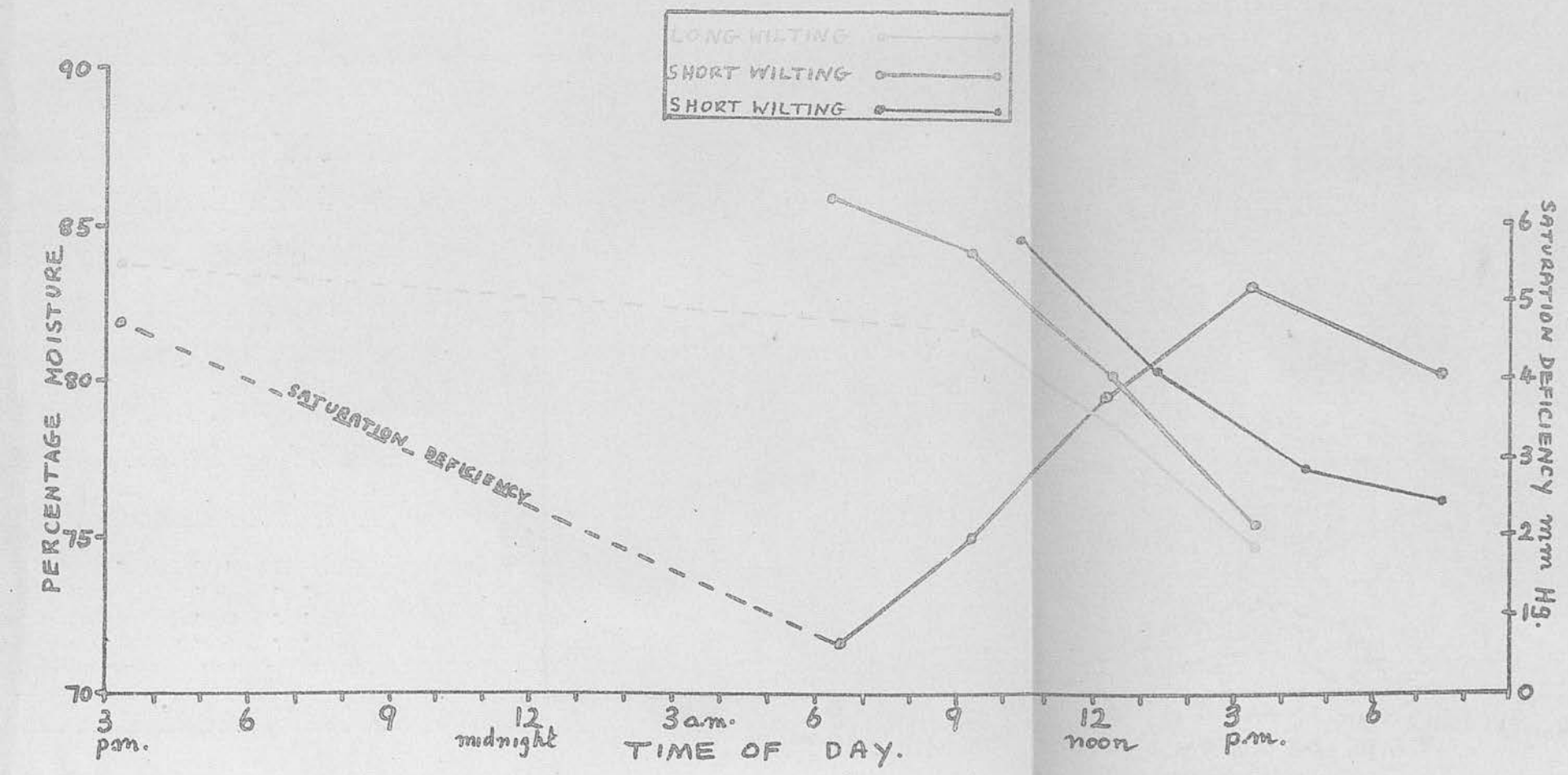
initial moisture content of 85.9 per cent. was the highest for the three groups. The reason for this large moisture drop is that wilting occurred over the best part of the day when drying conditions are best, i.e., between early morning and mid-afternoon.

TABLE 14. VARIATIONS IN PERCENTAGE MOISTURE CONTENT OF FRESH AND WILTED GRASS-CLOVER HERBAGE RELATIVE TO TIME OF CUTTING.

LONG PERIOD WILTING	
Crop Treatment	Moisture Content %
cut at 3.30 p.m.	84.0
collected at 9.30 a.m. after 18 hours wilting	81.7
collected at 12.30 p.m. after 21 hours wilting	78.6
collected at 3.30 p.m. after 24 hours wilting	74.5
overall per cent. unit drop =	9.5
SHORT PERIOD WILTING	
cut at 6.30 a.m.	85.9
collected at 9.30 a.m. after 3 hours wilting	84.2
collected at 12.30 p.m. after 6 hours wilting	80.3
collected at 3.30 p.m. after 9 hours wilting	75.4
overall per cent. unit drop =	10.5
cut at 10.30 a.m.	84.5
collected at 1.30 p.m. after 3 hours wilting	80.3
collected at 4.30 p.m. after 6 hours wilting	77.1
collected at 7.30 p.m. after 9 hours wilting	76.1
overall per cent. unit drop =	8.4

The least overall moisture drop, 8.4 per cent. units, occurred in the herbage cut at 10.30 a.m.

AVERAGE MOISTURE CONTENTS OF FRESH AND WILTED GRASS AND CLOVER UNDER DIFFERENT WEATHER CONDITIONS. 1953 AND 1954.



Only a small amount of wilting took place during the last three hour period, 4.30 p.m. to 7.30 p.m., since at that time of day drying conditions are usually poor. With these trials, therefore, wilting was almost wholly confined to the six hour period 10.30 a.m. to 4.30 p.m.

OTHER TRIALS USING LONG GRASS-CLOVER.

Other trials were carried out in 1954 to obtain further information on the changes of moisture content in (1) herbage cut and left lying overnight, (2) uncut herbage, and (3) herbage cut at different times of the day.

Herbage left lying overnight.

Six trials were carried out, two on the effect of rain, two on the effect of dew and two on the effect of a dry night with no rain or dew. For each trial five square yard plots were cut during the early evening between 7 p.m. and 7.30 p.m. Samples of the fresh material were collected immediately. The remaining grass was moved to one side and small swathes then placed on the bare stubble in each plot. The swathes were collected between 7 a.m. and 7.30 a.m. the following morning. Results are shown in the graphs on page 111 and in appendix 10.

TRIAL 1. A mixture of leafy cocksfoot and clover, 9-12 inches high, containing 22 per cent. crude

protein in the dry matter, was cut on 12th May. The evening was sunny and the grass moist with dew, S.D. value being 1.4. Moisture content of the fresh herbage was 83.7 per cent. During the night 5.2 m.m. rain fell and the following morning the moisture content had risen by 2.9 units to 86.6 per cent.

TRIAL 2. On 17th May leafy grass in the same field was used. The evening was fine though cool, S.D. value being 1.2. Fresh herbage moisture content was 82.2 per cent. Dew was lying on the swathes when collected the following morning. Moisture content had risen to 83.2 per cent.

TRIAL 3. On 19th May a different field was used consisting of cocksfoot, ryegrass and white clover. Sward height was 12-15 inches and crude protein content in the dry matter was 20.6 per cent. The weather was fine though the sky was overcast. Fresh herbage moisture content was 84.0 per cent. No rain fell overnight and the moisture content had fallen to 83.1 per cent. by the following morning.

TRIAL 4. On 27th May the same sward was used as in trial 3, the protein content now being 17.6 per cent. Crop height was 24 inches and the

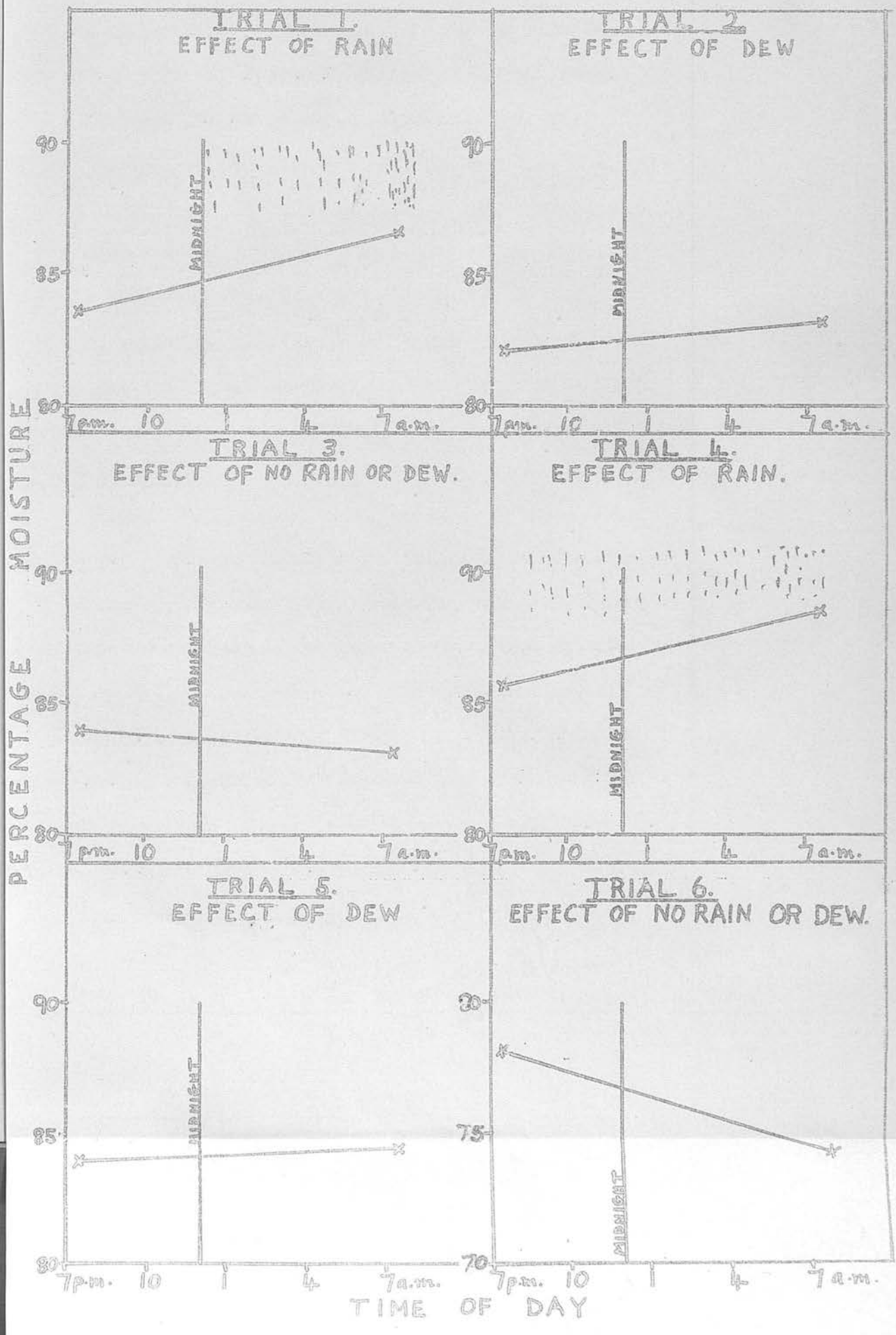
herbage was wet when cut. Moisture content was 85.7 per cent. The sky was overcast, there was no wind and S.D. value was 3.0. A thunderstorm occurred overnight with a fall of 6.8 m.m. of rain. The following morning the moisture content was 88.5 per cent., i.e. there was a per cent. unit rise of 2.8.

TRIAL 5. The same sward was used again on 11th June, the crude protein content now having fallen to 12.7 per cent. The herbage was 30 inches high and damp when cut. It contained 84.0 per cent. moisture. The evening was fine, there was a slight breeze and S.D. value was 2.5. A fall of dew raised the moisture content to 84.5 per cent. by the following morning.

TRIAL 6. This trial was carried out on 15th June during exceptionally good weather conditions. Another sward was used consisting of cocksfoot ryegrass and white clover. Herbage height was 24 inches. The evening was fine and S.D. value was 4.0. The moisture content was 78.1 per cent. and by the following morning it had fallen to 74.4 per cent., a drop of 3.7 units.

Excluding trial 6 which was carried out during an abnormally dry night, the results show that

TRIALS ON HERBAGE CUT AND LEFT LYING OVERNIGHT 1954.



moisture contents tended to increase overnight, rather than to decrease or to remain level. With two of the trials moisture contents were increased by approximately 3 per cent. units as a result of 6 m.m. rainfall. With another two trials dew caused a rise of 1 per cent. unit of moisture.

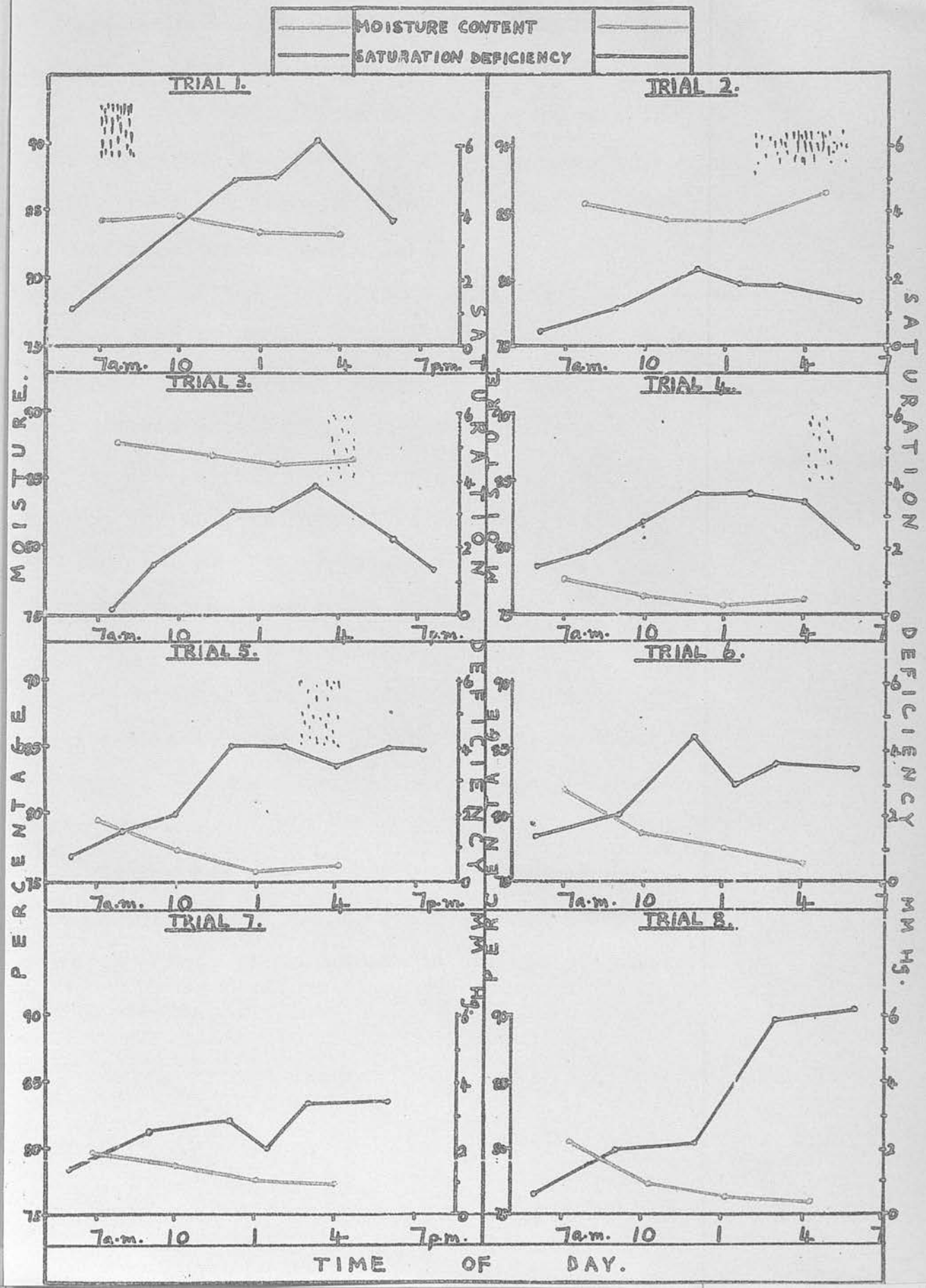
It will be remembered that for the main wilting trials the possibility of wilting taking place overnight was disregarded. No exceptionally good weather conditions occurred during those trials and from the above results it is clear that if wilting had occurred at night in one or two instances then the moisture drop would have been small.

Uncut herbage.

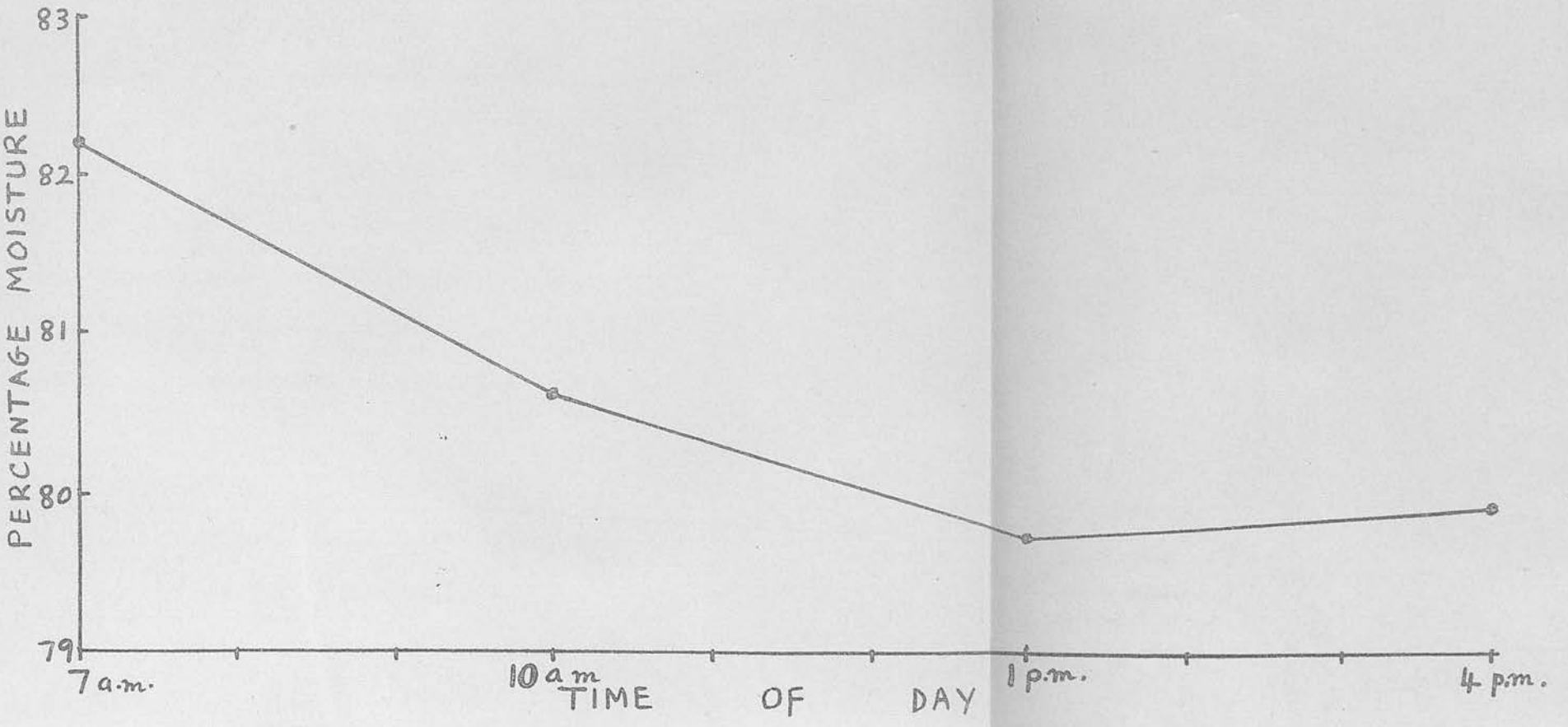
Eight trials were carried out to show the trend in moisture content of standing grass during different weathers. The herbage was cut during the day at three-hourly intervals, once in the early morning, once during mid-morning, again in the early afternoon and finally, in the late afternoon. Each main sample consisted of ten sub-samples cut at random over a thirty yard stretch of sward. With some of the trials long leafy material was used, with the others the herbage was cut at a stemmy stage of growth. Individual results are shown in the graph on

TRIALS ON UNCUT STANDING GRASS.

1954.



AVERAGE MOISTURE CONTENT OF UNCUT STANDING GRASS



AVERAGE MOISTURE CONTENT OF UNCUT STANDING GRASS

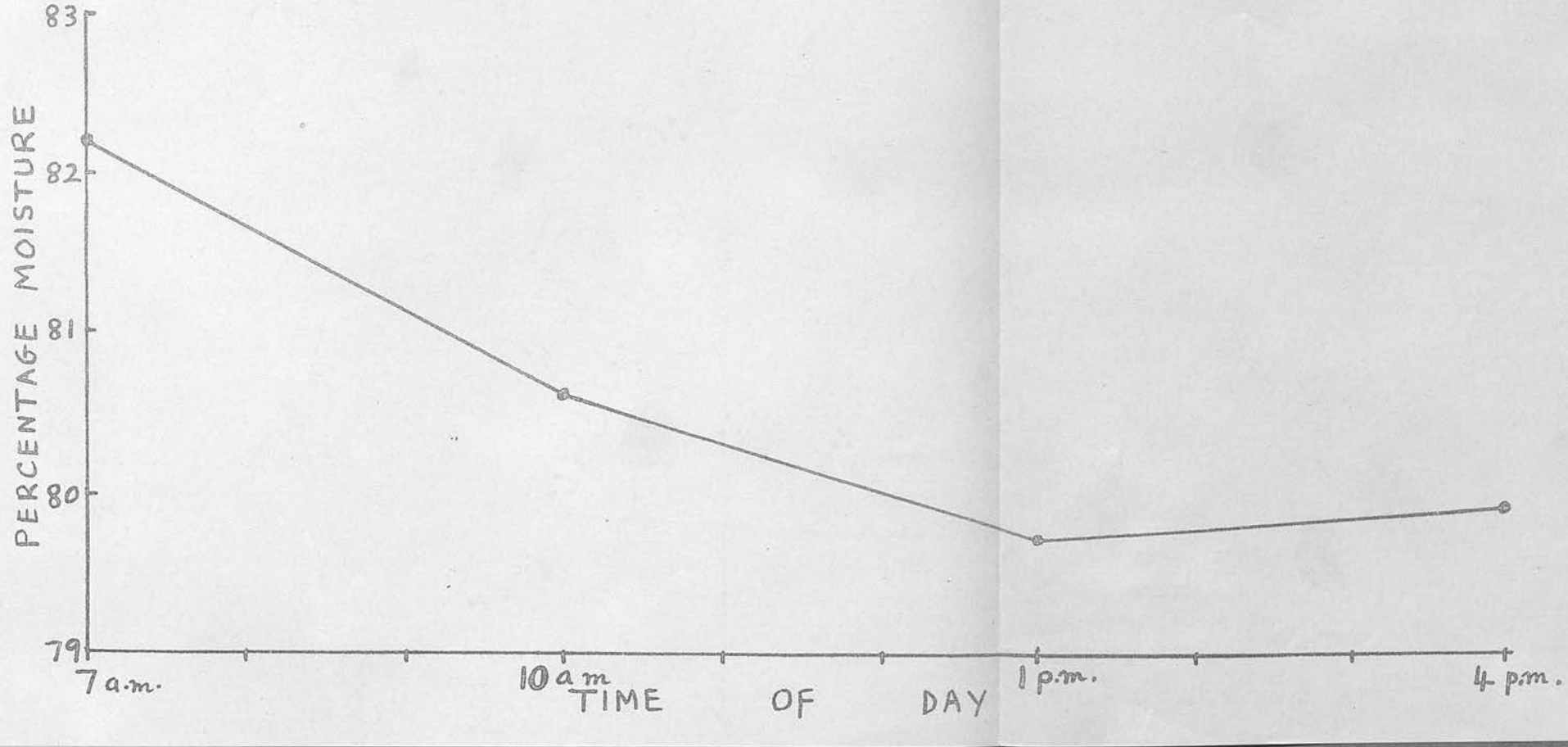


TABLE 15. PER CENT. UNIT MOISTURE DROP IN STANDING GRASS CUT AT DIFFERENT PERIODS OF THE DAY.

TRIAL	DATE	MOISTURE DROP IN PER CENT. UNITS		
		cut after 3 hours	cut after 6 hours	cut after 9 hours
1	20th May	+ 0.4	- 0.9	- 0.9
2	24th May	- 1.3	- 1.6	+ 0.7
3	28th May	- 1.1	- 1.7	- 1.1
4	15th July	- 1.2	- 1.8	- 1.6
5	20th July	- 2.4	- 3.8	- 3.5
6	29th July	- 3.2	- 4.3	- 5.5
7	31st July	- 0.6	- 1.6	- 2.0
8	4th August	- 3.2	- 4.0	- 4.5
AVERAGES		- 1.6	- 2.5	- 2.3

Herbage cut at different times of the day.

In view of the fact that cutting was performed at irregular intervals for the main wilting trials it was decided in 1954 to carry out three small trials with the object of obtaining more information on the relationship between time of cutting and variations of moisture content within wilting herbage.

A thin crop was used, estimated to yield between 1 and 2 tons per acre. The sward was a one year ley aftermath consisting of Italian ryegrass and broad red clover. The grass was at a mature stage when cut and there was little clover. The crude protein content was low, 8.1 per cent. in the dry matter. Appendix 12 shows the layout of the plots and also gives

details on weather, weights of fresh and dry herbage and percentage moisture contents. For each trial a total of 12 randomized plots in replicates of three were used and each plot contained seven square yard sub-plots. Cutting was performed every three hours, 6.30 a.m., 9.30 a.m., 12.30 p.m. and 3.30 p.m. Every two hours three replicate samples were collected for moisture determinations, commencing at 6.30 a.m.

It was necessary to abandon one of the trials owing to the onset of very wet weather, but it is worth recording that the moisture content of the early morning cut grass increased from 74 per cent. to 82 per cent. during a period of six hours continuous rain or drizzle. Unfortunately no corresponding datum for a normal yielding crop is available.

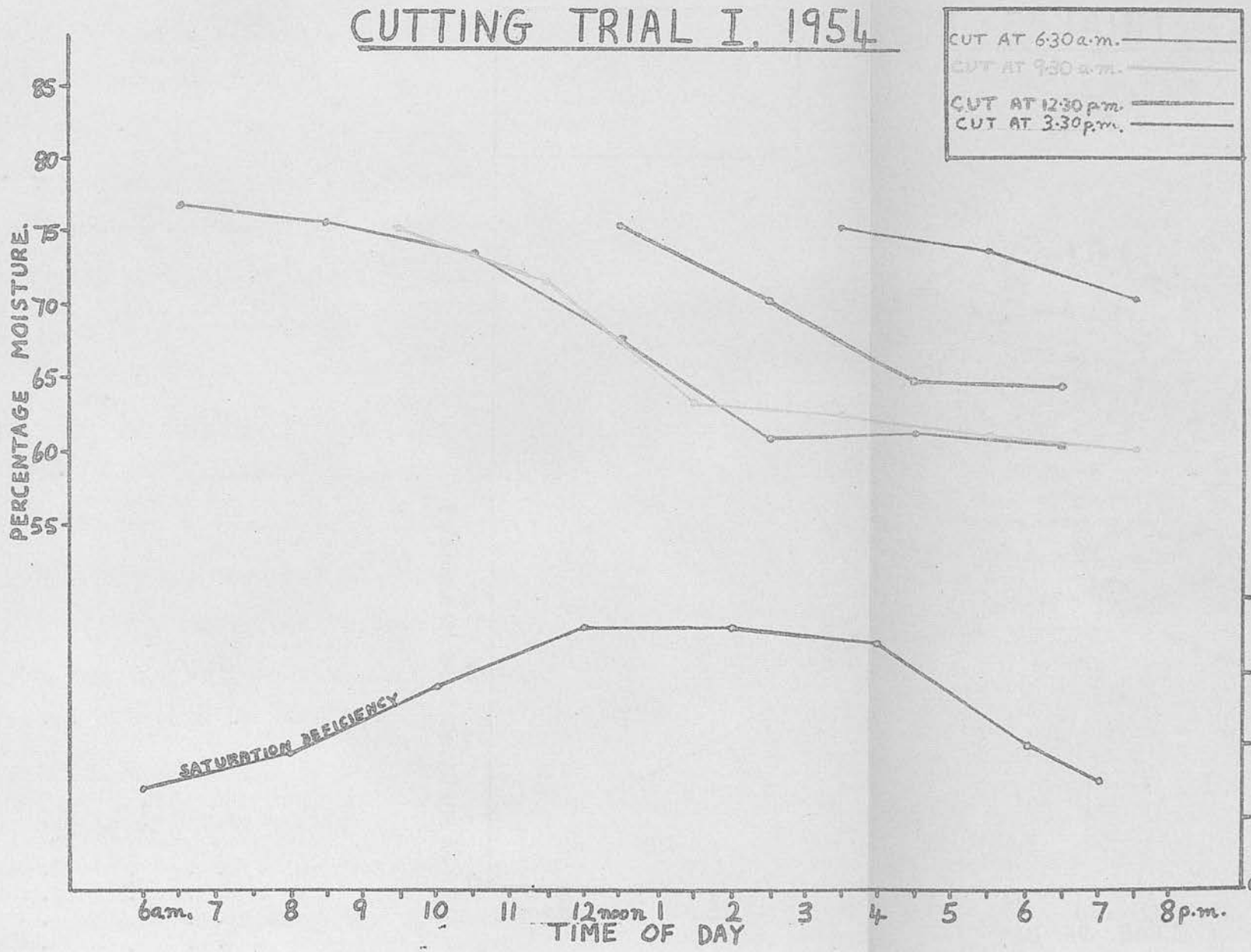
The results for the other two trials are shown in tables 16 and 17 and in the two accompanying graphs. From these it will be observed that there was a very marked relationship between the fall in moisture content and thickness of crop compared to the previous results.

TRIAL 1.

Weather conditions on July 16th were classed as poor. Early in the morning the sky was overcast with stratus and stratocumulus and the air was cool. There was no dew on the grass. Some drizzle fell during mid-morning but by midday the cloud had broken to seven-tenths and air temperature had risen to 60°F. These conditions continued until 4 p.m. when again it became cool. The sky was overcast with altostratus and at 4.30 p.m. there was a shower of rain, too small to be registered on the rain gauge. For the rest of the day there was intermittent fine drizzle. Total sunshine was 1.1 hours and S.D. value was 3.6 at midday. Average results are given in the graph on page 119 and in table 16 below.

TABLE 16. THE RELATIONSHIP BETWEEN TIME OF CUTTING AND MOISTURE CONTENT OF GRASS-CLOVER HERBAGE CUT FOR WILTING.
(each result is a mean of three replicates)

Cut at 6.30 a.m.		Cut at 9.30 a.m.		Cut at 12.30 a.m.		Cut at 3.30 a.m	
Time of Day	Moisture Content %	Time of Day	Moisture Content %	Time of Day	Moisture Content %	Time of Day	Moisture Content %
6.30a.m.	76.9	9.30a.m.	75.1	12.30p.m.	75.5	3.30p.m.	75.1
8.30a.m.	75.7	11.30a.m.	71.6	2.30p.m.	70.1	5.30p.m.	73.6
10.30a.m.	73.5	1.30p.m.	63.3	4.30p.m.	64.8	7.30p.m.	70.2
12.30p.m.	67.8	3.30p.m.	62.5	6.30p.m.	64.2		
2.30p.m.	60.9	5.30p.m.	61.0				
4.30p.m.	61.1	7.30p.m.	60.2				
6.30p.m.	60.4						
overall (16.5) drop in per (14.9) cent. units (11.3) of moisture(4							


CUTTING TRIAL I. 1954
CUT AT 6:30 a.m.
CUT AT 9:30 a.m.
CUT AT 12:30 p.m.
CUT AT 3:30 p.m.
PERCENTAGE MOISTURE.
85
80
75
70
65
60
55
SATURATION DEFICIENCY
SATURATION DEFICIENCY MM Hg.
4
3
2
1
0
6a.m. 7 8 9 10 11 12noon 1 2 3 4 5 6 7 8p.m.
TIME OF DAY

than in the corresponding materials cut for the main wilting trials but the overall drop, even during poor weather, was greater than that of the thicker sward wilted during very good weather. In the first column of results in table 16 it will be seen that after nine hours of exposure the moisture drop amounted to 16 per cent. units. This was approximately twice the amount of wilting which took place during the main trials with a normal yielding crop exposed to the best of the poor weather conditions over a period of one day. In this trial the 6.30 a.m. cut herbage reached the 70 per cent. level of moisture after five hours of wilting. A similar level was reached after only two hours with herbage cut at 9.30 a.m. and after four hours with the 12.30 p.m. cut plots. With the plots cut at 6.30 a.m. the 60 per cent. level was attained after twelve hours wilting, and after ten hours in the herbage cut at 9.30 a.m.

TRIAL 2.

Weather conditions were classed as moderate - good when this trial was carried out on 20th July. During the previous night 4.4.m.m. rain had fallen so that the plots were wet when the first cutting was performed at 6.30 a.m. Herbage moisture content was only 80.8 per cent. Weather conditions

during the early morning were poor. The air was cool and there was slight drizzle, the sky being overcast with stratus and stratocumulus. By 8 a.m., however, the low cloud had disappeared and later the stratocumulus changed to seven-tenths fair weather cumulus. By early evening there was only two-tenths cumulus. The day was generally warm and dry, except for a few small showers which fell between 3.30 p.m. and 4.30 p.m. Total sunshine was 4.1 hours and at midday S.D. value was 4.0.

Average results are shown in the graph on page 123 and in table 17. In contrast to the first trial there was a much greater fall in moisture content in the standing crop as the day proceeded. Even though weather conditions were only moderately good there was a moisture drop of as much as 5 per cent. units in the fresh herbages between 6.30 a.m. and 3.30 p.m. Rate of wilting was greatest between midday and mid-afternoon. During the six hours following the 12.30 p.m. cutting the overall moisture drop of 12.7 per cent. units amounted to 60 per cent. of that which occurred over the twelve hour period, 6.30 a.m. to 6.30 p.m. The corresponding moisture drop of 9.3 units during the four hours following the 3.30 p.m. cutting amounted to as much as 45 per

CUTTING TRIAL II 1954

cent. of the full day's drop. It will be recalled that with the main trials the moisture drop occurring in a normal yielding crop, during moderate - good weather, varied between 8 and 12 per cent. units.

TABLE 17. THE RELATIONSHIP BETWEEN TIME OF CUTTING AND MOISTURE CONTENT OF GRASS-CLOVER HERBAGE CUT FOR WILTING.
(each result is a mean of three replicates)

Cut at 6.30 a.m.		Cut at 9.30 a.m.		Cut at 12.30 p.m.		Cut at 3.30 p.m.	
Time of Day	Moisture Content %	Time of Day	Moisture Content %	Time of Day	Moisture Content %	Time of Day	Moisture Content %
6.30a.m.	80.8	9.30a.m.	77.2	12.30p.m.	75.8	3.30p.m.	75.5
8.30a.m.	79.7	11.30a.m.	72.8	2.30p.m.	71.2	5.30p.m.	71.2
10.30a.m.	75.6	1.30p.m.	69.7	4.30p.m.	67.2	7.30p.m.	66.2
12.30p.m.	70.6	3.30p.m.	67.4	6.30p.m.	63.1		
2.30p.m.	67.0	5.30p.m.	63.1				
4.30p.m.	65.1	7.30p.m.	58.4				
6.30p.m.	60.3						
overall (20.5) drop in per (18.8) cent. units (12.7) of moisture (9.3)							

In the plots cut at 6.30 a.m. the 70 per cent. moisture level was reached after six hours of wilting. A similar level occurred after four hours with the plots cut at 9.30 a.m. and only after two hours in the materials cut at 12.30 p.m. and 3.30 p.m. After twelve hours the 60 per cent. level was reached in the 6.30 a.m. cut herbage and after nine hours in the plots cut at 9.30 a.m.

The important points arising out of these trials are the rapidity with which wilting occurs in a thin crop, even when the herbage is exposed

to poor weather conditions, and the occurrence of low initial moisture contents compared to those in an average yielding crop. The 60 per cent. level can be obtained after about 9 hours of wilting and the 70 per cent. level after 6 hours or less, depending on whether cutting takes place in early or mid-morning, or early or mid-afternoon.

WILTING TRIALS USING BRUISED GRASS-CLOVER HERBAGE.

In view of the interest now being shown towards mechanical bruising of herbage for silage it was decided in 1954 to carry out further wilting trials, this time with the object of determining whether the rate of wilting was greatest in bruised herbage or in ordinary mown material.

The crop was bruised with the aid of the SHEARMOW forage harvester from which the elevator had been removed. This enabled the cut herbage to fall on the ground in the form of a swathe. The bruiser unit consisted of a rotor fitted with two blades which revolved at high speed close to the ground. When the machine was drawn across the field the standing crop was sheared by the impact of the rotor blades. The herbage was then thrown between the rotor and a deflector plate, the position of the latter determining the amount of bruising which occurred.

In preliminary tests with the SHEARMOW two difficulties arose. The first concerned the amount of bruising required for satisfactory wilting to take place. When the maximum bruising setting was used the physical state of the herbage was similar to that of grass-clover herbage which has been passed through a SILORATOR, i.e. it was lacerated. Hence the material had lost its structural strength, it settled rapidly in the swathe and was in an unsuitable condition for wilting. Various machine settings were tried and that for minimum bruising was found the most satisfactory because the herbage was deposited on the ground in a 'fluffy' condition. It was also found that a slow forward tractor speed helped to produce the required type of swathe.

The second difficulty concerned the laying down of even swathes free from lumps. Satisfactory results were eventually obtained though the swathes were not as even as those produced from a mowing machine.

For each of four short period wilting trials (trials 9, 10, 11 and 12) two swathes were used, a bruised swathe and, adjacent to it, a control swathe of mown herbage. Parallel to the swathes a line of markers was placed on the ground at intervals of one yard over a distance of thirty-

two yards. In this way the swathes were divided into plots for sampling purposes. A diagram is given in appendix 13.

The bruised and mown swathes differed from each other with respect to both their width and depth. The cutting width of the SHEARMOW was $3\frac{1}{4}$ ft. and this gave a swathe width of 2 ft. compared to a 4 ft. swathe from the mower possessing a 5 ft. cutter bar. The bruised swathes were 'fluffy' and varied in depth from 6 to 12 inches whereas the depth of the mown swathes was approximately 5 inches. For experimental reasons it would have been preferable to produce swathes of equal width but in the circumstances this was impossible.

With each trial cutting was performed in the early morning and samples of the fresh materials were collected immediately. Further sampling was done at three hourly intervals and the final collection period was during mid-afternoon after 9 hours of wilting. The diagram in appendix 13 shows that ordinary moisture determinations were obtained by sampling five 2 yd. sections of each swathe. Extra care was needed in sampling the bruised herbage. Meteorological data and full information on fresh and dry herbage weights and percentage moisture contents are also given in the appendix.

Individual results.

TRIAL 9. On 24th May wet leafy grass-clover herbage, 1¼ feet high, was cut at 6.30 a.m. The crude protein content in the dry matter was 19.9 per cent. Weather conditions for the trial as a whole were classed as very poor. Total sunshine for the day was 0.5 hours and the highest recorded S.D. value was 2.4. There was a strong breeze throughout the day and the maximum recorded air temperature was 50°F. The air was cool and damp and the sky was overcast with altostratus. These conditions remained the same until 2 p.m. when it began to drizzle. Rain followed later and the weather continued wet for the remainder of the trial. Table 18 below shows that there was little difference in moisture.

TABLE 18. PERCENTAGE MOISTURE CONTENTS OF BRUISED-WILTED AND MOWN-WILTED GRASS-CLOVER HERBAGE.
(each result is a mean of five replicates)

CROP TREATMENT	BRUISED SWATHE	MOWN SWATHE
fresh herbage	86.0	86.0
wilted 3 hours	84.3	83.4
wilted 6 hours	82.2	82.8
wilted 9 hours	83.1	83.6
overall moisture drop in per cent. units	= 2.9 and	2.4

contents of either the bruised or mown swathe.

A small amount of wilting took place during the

first six hours. Thereafter there was a slight rise in moisture content due to rain.

TRIAL 10. This and the following two trials were carried out in a different field to that used for trial 9. The sward of grass and clover was 2 feet high and at a mature stage of growth, the crude protein content in the dry matter being 13.6 per cent. Wet herbage was cut at 6.45 a.m. on 29th July. Total sunshine for the day was 7.4 hours, air temperatures ranged between 55°F. and 60°F. and the maximum recorded S.D. value was 4.4. Cumulus cloud varied in amount from six to nine-tenths. Weather conditions should have been classed as moderate - good but owing to a strong wind the amount of wilting was much greater than would have been expected from the conditions mentioned above.

Table 19 indicates that slightly more wilting occurred in the bruised swathe than in the mown swathe. During the first six hours the rate of wilting was about the same in both swathes, but during the final three hour period the fall in moisture was greater in the mown material.

TABLE 19. PERCENTAGE MOISTURE CONTENTS OF BRUISED-WILTED AND MOWN-WILTED GRASS-CLOVER HERBAGE.
(each result is a mean of five replicates)

CROP TREATMENT	BRUISED SWATHE	MOWN SWATHE
fresh herbage	81.9	82.3
wilted 3 hours	77.6	77.3
wilted 6 hours	70.8	71.0
wilted 9 hours	64.9	62.5
overall moisture drop in per cent. units =	17.0	and 19.8

TRIAL 11. The herbage was slightly damp when cut at 6.30 a.m. on 31st July. Weather conditions should again have been classed as moderate - good but, as with trial 10, there was a strong wind which caused rapid wilting. Total sunshine for the day was 4.6 hours and the maximum recorded figures for air temperature and S.D. value were 57°F. and 3.4 respectively. There was a light shower of rain in the early afternoon but it was too small to be recorded on the rain gauge. Table 20 shows a similar trend in moisture contents as occurred with trial 10, the wilting rates being the same during the first six hours and greater in the mown material during the final period.

TABLE 20. PERCENTAGE MOISTURE CONTENTS OF BRUISED-WILTED AND MOWN-WILTED GRASS-CLOVER HERBAGE.
(each result is a mean of five replicates)

CROP TREATMENT	BRUISED SWATHE	MOWN SWATHE
fresh herbage	79.7	79.1
wilted 3 hours	75.0	75.1
wilted 6 hours	70.9	68.9
wilted 9 hours	67.1	64.1
overall moisture drop in per cent. units =	12.6 and	15.0

TRIAL 12. By August 4th the crude protein content in the dry matter had fallen to 13.0 per cent. The herbage was wet when cut at 7 a.m. Weather conditions during the whole day were very good, there being from one- to six-tenths cumulus cloud, a moderate breeze and 12.4 hours of sunshine. Maximum recorded figures for air temperature and S.D. value were 63°F. and 5.9 respectively.

Table 21 shows that there was little difference in moisture contents of the two swathes and that the overall moisture drop was the same in both instances.

TABLE 21. PERCENTAGE MOISTURE CONTENTS OF BRUISED-WILTED AND MOWN-WILTED GRASS-CLOVER HERBAGE.
(each result is a mean of five replicates).

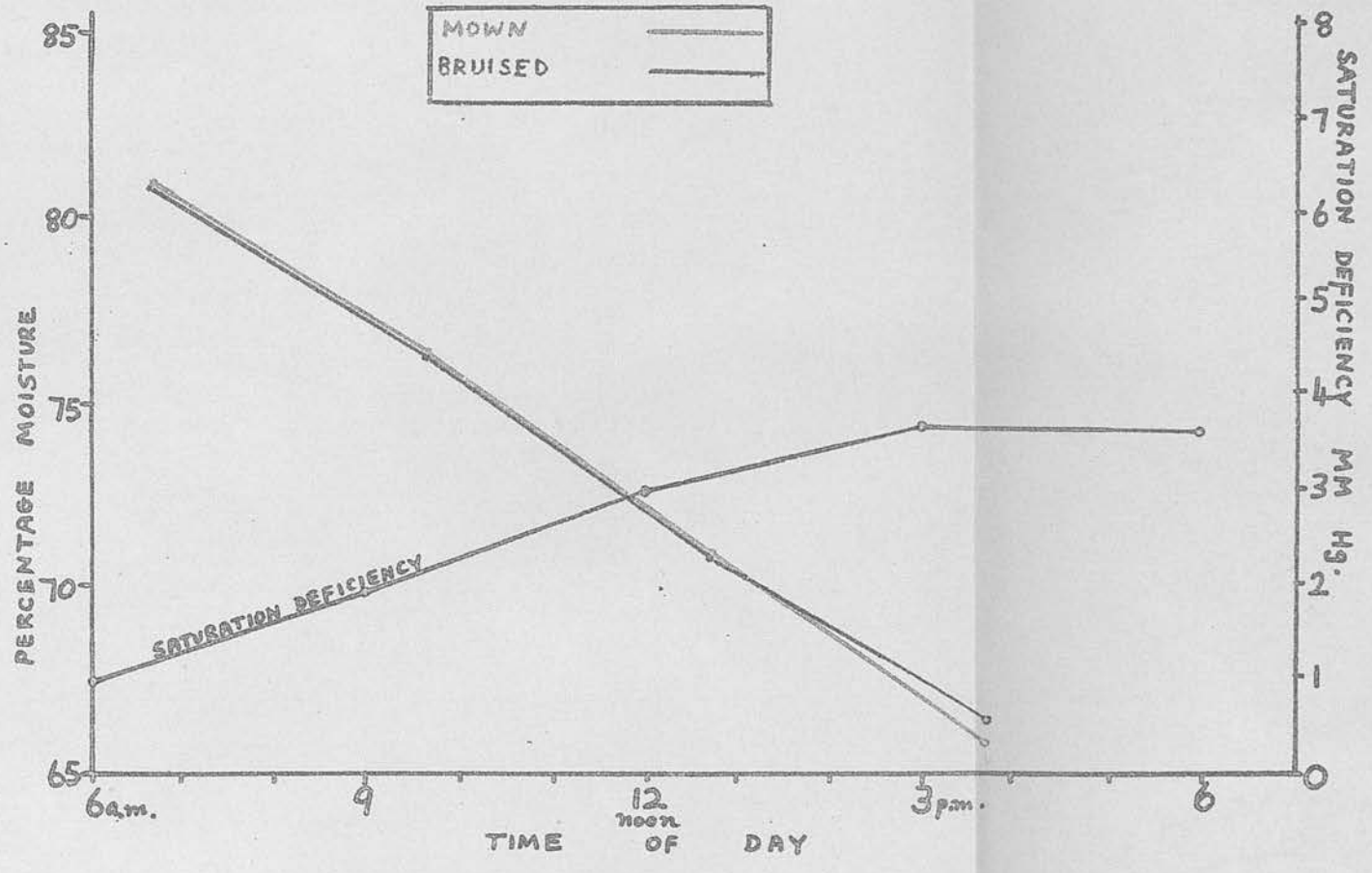
CROP TREATMENT	BRUISED SWATHE	MOWN SWATHE
fresh herbage	79.5	79.8
wilted 3 hours	73.2	74.3
wilted 6 hours	61.2	64.7
wilted 9 hours	55.3	55.2
overall moisture drop in per cent. units =	24.3	and 24.6

It is interesting to note, however, that the rate of wilting was again greater in the mown swathe during the final three hour period than it was during the final period with the bruised swathe.

Combined results.

Average results for the four trials are shown in the graph on page 133. It shows that there was negligible difference in the rate of wilting with either material. The reason why the bruised swathes did not wilt at a faster rate than the mown material was due to the way in which these swathes gradually settled down on the ground. Visual inspection of bruised swathes during preliminary trials had indicated that the tops dried out very quickly and it was, therefore, decided to investigate the variations occurring in moisture contents of the swathes used for the

AVERAGE MOISTURE CONTENTS OF MOWN AND BRUISED GRASS-CLOVER HERBAGE GIVEN SHORT PERIODS OF WILTING. 1954



ensuing trials 9-12. During each trial five replicate one yard sections of each swathe were separated into upper and lower halves for individual moisture determinations. Full results are given in appendix 14.

The average results, given in table 22 below, relate to swathes wilted for 9 hours and show that

TABLE 22. PERCENTAGE MOISTURE CONTENTS OF UPPER AND LOWER PORTIONS OF BRUISED-WILTED AND MOWN-WILTED GRASS-CLOVER SWATHES.
(each result is a mean of five replicates)

TRIAL	BRUISED HERBAGE		MOWN HERBAGE	
	top of swathe	bottom of swathe	top of swathe	bottom of swathe
9	77.0	84.4	82.3	83.6
10	40.7	71.6	57.0	65.4
11	46.1	72.8	59.9	67.1
12	25.3	55.8	50.9	60.6

whereas very low moisture contents occurred in the top portions of bruised swathes those in the lower portions, except for trial 12, remained high. Even in trial 9, carried out during very poor weather conditions, the moisture content was much lower in the top than in the bottom half of the swathe after nine hours exposure. The high moisture contents would be due to poor circulation of air through the bottom of the swathes. On the other hand the table shows that the variation of moisture in the open mown swathes was not nearly so great which would be due to air being able to

circulate more freely throughout the whole depth of swathe.

Losses due to wilting; long and bruised herbage.

During most of the wilting trials an investigation was made into the losses of fresh and dry matter sustained in herbage during the maximum periods of wilting, i.e. 24 hours for the long trials and 9 hours for the short trials. Similar work was carried out on bruised herbage during the 1954 trials. Full information on weights of fresh, wilted and oven dried herbage and on percentage losses and gains are given in appendix 15.

The field technique employed in the 1953 trials and the method of calculating the losses were as follows: the C sub-plot materials were weighed immediately after they had been cut. They were then placed in the form of small swathes onto sections of wire mesh, each 1½ ft. x 1½ ft., which had been fixed close to the bare plots immediately after cutting. (With trials 9-12 it was necessary to place the bruised swathes onto wire frames of very fine mesh to prevent loss of small pieces of leaf and stem.) At the end of the wilting periods the contents of each wire frame was reweighed and then transported to the laboratory along with the F, A and B samples for oven drying and subsequent moisture determinations.

Calculation of fresh weight losses was straightforward, this being the difference in weight of the fresh and wilted herbage, taken as a percentage of the fresh weight. In calculating the losses and gains in dry matter the moisture contents of the freshly cut F sub-plots were regarded as being the moisture contents of the freshly cut C sub plots, the reason being that there was insufficient herbage in each C sub-plot to provide a normal size sample for a moisture determination as well as one for making into a swathe.

It was realised that the above procedure might increase the experimental error. Two trials were, therefore, carried out with leafy herbage to determine the magnitude of the variation in moisture contents within freshly cut square yard plots. For each trial ten plots were used and each plot was divided into four quarters to represent sub-plots. All of these were collected immediately for moisture determinations. The results, given in appendix 16, show that on the whole differences were not large - the mean differences* for the two trials being 1.7 and

* by difference is meant that between the highest and the lowest observation.

2.2 per cent. units of moisture respectively. But when differences of this order are considered from the point of view of dry matter estimations they become quite important. With the 1954 trials it was, therefore, decided that losses should be calculated using percentage moisture figures obtained from herbage sampled in a different way. Briefly, samples were now taken over the whole plot and bulked, rather than from the individual sub-treatments.

Fresh matter losses.

(Full results are given in appendix 15,) That large reductions in fresh weight occur even when herbage is given moderate periods of wilting is clear from table 23. The results for the 1953 trials 2-5 refer to long herbage wilted during moderate - very good weather conditions and show that the fresh weight losses were similar for long period wilting, 43 per cent., as for short period wilting, 45 per cent. The corresponding losses for the 1954 trials carried out during poor - very poor weather conditions were 23 per cent. and 19 per cent. respectively.

TABLE 23. PERCENTAGE FRESH MATTER LOSSES OF GRASS-CLOVER HERBAGE.

(each result is a mean of five replicates)

TRIAL NUMBER	1953	
	LONG HERBAGE WILTED FOR 24 hours	9 hours
2	38	41
3	50	50
4	38	43
5	45	
COMBINED AVERAGE	43	45
TRIAL NUMBER	1954	
6	44	37
7	6	24
8	19	32
COMBINED AVERAGE	23	31
TRIAL NUMBER	BRUISED HERBAGE WILTED FOR 9 hours	LONG HERBAGE 9 hours
9	28	+ 1
10	63	52)
11	55	43)48
12	66	49)
COMBINED AVERAGE	53	36

It is interesting to note that for trials 10, 11 and 12 the average fresh loss of 48 per cent. in the long herbage wilted under moderate - very good weather was of the same order as that for the 1953 trials carried out under similar

conditions.

With trials 9-12 the average fresh weight loss in the bruised swathes (53 per cent.) was much greater than in the corresponding mown materials (36 per cent.) due to the bruised herbage being unavoidably disturbed when weighed and also when it was placed, in the form of swathes, onto wire frames. These results emphasise the rapidity with which wilting takes place in bruised herbage if air can circulate freely through it. The rapidity of wilting is especially noticeable with trial 9 which was carried out during very poor weather conditions. Here the loss in weight was 28 per cent. whereas there was no loss in the corresponding long herbage. Excluding the bruised materials the overall fresh weight loss was 45 per cent. in moderate - very good weathers and 19 per cent. in poor - very poor weathers.

Dry matter losses.

(Full results are given in appendix 15.) In contrast to the results for fresh weight losses there appeared to be no correlation between the dry matter changes and type of weather experienced during wilting. Table 24 shows that with many of the trials, gains rather than losses occurred. It is probable that these are mainly due to random error. The table shows that the average gains

are of a low order, between 1 and 3 per cent. (excluding the results carried out on bruised material and the large gain of 10 per cent. for long wilting trial 8) which do not differ appreciably from zero. From this it may be concluded that losses of dry matter during wilting periods of up to one day may be disregarded.

TABLE 24. PERCENTAGE DRY MATTER LOSSES AND GAINS OF GRASS-CLOVER HERBAGE.

(each result is a mean of five replicates)

TRIAL NUMBER	1953	
	LONG HERBAGE WILTED FOR 24 hours	9 hours
2	+ 5	+ 2
3	+ 2	+ 3
4	+ 7	± 0
5	- 2	
COMBINED AVERAGE	+ 3	+ 2
TRIAL NUMBER	1954	
6	- 2	- 5
7	- 1	+ 3
8	+ 10	+ 5
COMBINED AVERAGE	+ 2	+ 1
TRIAL NUMBER	BRUISED HERBAGE WILTED FOR 9 hours	MOWN HERBAGE 9 hours
9	± 0	+ 3
10	- 2	- 2
11	+ 4	+ 2
12	- 5	- 2
COMBINED AVERAGE	- 1	+ 1

DISCUSSION.

Results obtained for changes in moisture content of uncut herbage agree closely with those of Greenhill (1936a) who obtained a moisture drop of approximately 3 per cent units, all in the form of external moisture, between morning and afternoon. Edinburgh data on rate of wilting gave average hourly moisture drops of approximately 0.5 per cent units and 1.0 per cent units, depending on whether the wilting period extended over 24 hour periods or for 9 hours during the day. These results do not differ markedly from those found by other workers (see page 18-21).

It is entirely agreed with Murdoch (1953) that it would be useless for farmers to cut grass late in the afternoon and expect it to have wilted sufficiently for collection early the following morning, and it is not agreed with Mitchell and Shepperson (1953), and others, who maintain that cutting should be postponed until the dew has disappeared from the herbage.

There is no doubt that wilting proceeds more rapidly in bruised than in mown herbage though due to the type of bruising machine employed, and the way in which the treated herbage was deposited on the ground, rapid drying only occurred in the upper exposed portions of swathes, as was also shown by Greenhill (1936), but to a lesser extent than in

bruised herbage.

If a greater number of wilting trials had been carried out, and hence more related data on precipitation, sunshine, air temperature and saturation deficiency collected, greater reliance could have been placed on the weather classification (see page 101-2) and on its relationship to the degree of wilting (see table 12 , page 103). It is clear, however, that the single condition of saturation deficiency is in itself a valuable guide.

Sufficient evidence is available in the literature to show that field dry matter losses during wilting periods of one day are small, up to about 3 per cent (see pages 11-13). Fleischmann (1912) is the only known investigator to have found true gains in dry matter and it can only be assumed that the gains obtained at Edinburgh were, as Fleischmann had maintained, due to photosynthesis continuing for a period immediately following cutting. Only when severe wilting is carried out over a period of some days will appreciable dry matter losses occur. Indeed, Dijkstra and Brandsma (1955) sometimes found that as much as half the total dry matter loss of severely wilted silage was due to losses occurring in the field.

It is interesting to note that the results obtained for fresh weight losses compare favourably

with those of other investigators. Greenhill (1936) mentions an experiment carried out by Watson in 1931 who found that grass herbage lost 31.5 per cent. of its weight after 6 hours wilting during good weather conditions. At Edinburgh an average fresh weight loss of approximately 45 per cent was obtained after 9 hours wilting during similar weather conditions, and Studer (1955) maintains that green fodder will lose about 50 per cent of its weight after a wilting period of one day during sunny weather.

SUMMARY AND CONCLUSIONS

1. In S.E. Scotland it is possible to carry out the partial wilting process even during apparently unsuitable weather conditions.
2. In good weather conditions grass-clover herbage can be wilted to around the 70 per cent. level of moisture over a period of one day.
3. Average results for all weather conditions except continuous rain showed a moisture drop of 9.5 per cent. units (e.g. 84.0 to 74.5%) irrespective of whether the swathes lay exposed for 24 or 9 hours. Moisture contents fell, on the average, from the 85 per cent. level to the 75 per cent. level.
4. Most wilting occurs between early morning and mid-afternoon. Rate of wilting between mid-afternoon and early evening is very slow; results of four trials gave an average drop of only 1 per cent. unit of moisture. Except during exceptionally dry weather no wilting occurs overnight from 7 p.m. to 7 a.m.
5. During moderate - very good weather there was an average moisture drop of 12.8 per cent. units after 24 hours and 11.2 units after 9 hours. There was a slightly greater advantage in wilting for 24 hours than for 9 hours. On the average, moisture contents fell from 83-85 per cent. to 70-74 per cent.

Increases in amounts of dry matter varied approximately from 50 to 100 per cent.

6. During poor - very poor weather there was an average moisture drop of 4 per cent. units after 24 hours and 6.5 units after 9 hours of wilting. Here there was a slightly greater advantage in wilting for 9 hours than for 24 hours. On the average, moisture contents fell from 85-86 per cent. to 80-81 per cent. Increases in amounts of dry matter varied approximately from 5 to 50 per cent.

7. Regrouping the results showed that in very good weather moisture drop exceeded 12 per cent. units. In moderate - good weather it varied from 8 to 12 units, and from 3 to 8 units in poor weather. In very poor weather the drop was less than 3 per cent. units.

8. It was often noted that wilting was not greatly impeded by rain showers and that the moisture content continued to fall in swathes covered with droplets of water from previous rain.

9. The results of two trials suggest that swathes left lying exposed to rain do not become wetter than a standing crop. It is thought that the top of a swathe acts as a kind of thatch.

10. Except during periods of continuous rain it would seem that the moisture content of herbage cut and left to lie in the field for one day

will never be higher than that contained in the original fresh herbage. It is concluded that even during poor weather conditions (occasional showers or drizzle, overcast, cool) there would be no disadvantage in always cutting in advance of ensilage.

11. If cutting is to be performed in the early morning then no advantage is to be gained by waiting until the crop has dried out.

12. The time of cutting is of no importance provided the herbage receives a total of about 9 hours of wilting between early morning and mid-afternoon. The wilting can either be carried out all on one day or partly on one day and partly on the next day.

13. The moisture content of a thin crop with a yield of about 2 tons per acre will probably be much lower than that of an average crop yielding between 5 and 6 tons per acre. The rate of wilting in a thin crop is rapid and even in poor weather conditions the moisture content may fall to the 60 per cent. level over a period of 8 hours.

14. Rate of wilting was the same in bruised herbage as in mown herbage, this being due to the way in which the bruised swathes settled down on the ground. But the tops of bruised wilted swathes were always much lower

in moisture content than the tops of mown swathes and this indicates that good results would have been obtained had the bruised swathes been scattered over the ground.

15. Fresh weight losses in long herbage wilted for 24 and 9 hours averaged 45 per cent. during moderate - very good weather. The average fresh weight loss during poor - very weather was 19 per cent.

16. Both losses and gains occurred in dry matter. There was an overall average gain of between 1 and 3 per cent. From this it is concluded that changes in dry matter content over a period of one day may be disregarded.

SECTION 3

EXPERIMENTAL SILAGES

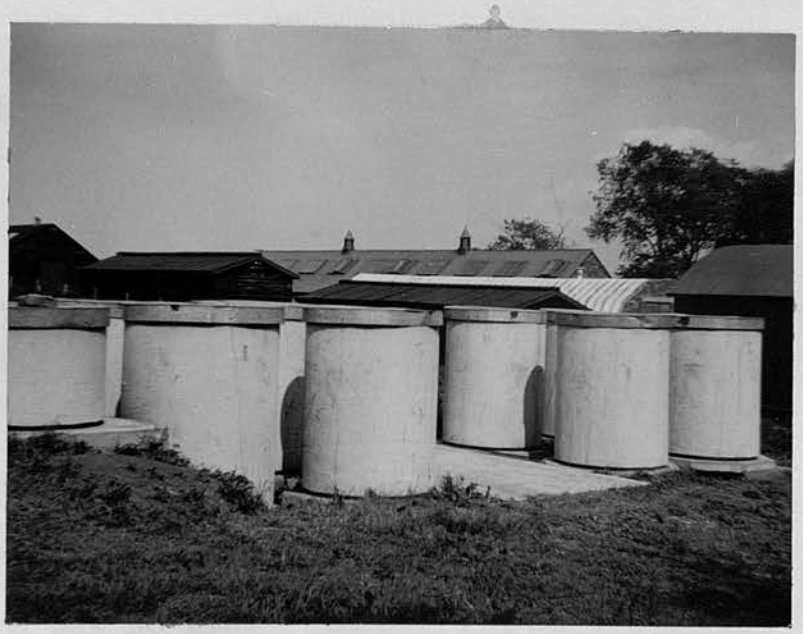
During the summers of 1953, 1954, and 1955 silages were made at Boghall Farm from fresh and wilted grass and clover crops using 6' x 4½' experimental silos. The silos are shown in photograph 1 on page 150 while photograph 2 shows the control box containing the galvanometer used during 1954 and 1955 for recording the temperatures in each silo.

The purpose of the investigation was to try out in practice, on a small scale, the partial wilting method and to obtain information on the quality, losses and digestibility of the ensiled materials. Some of the silages were made from herbage given the single treatment of wilting and some from material given two treatments, either bruising + wilting or wilting + preservative.

Full data on the quantities of herbage ensiled and removed from the silos and on the composition, quality and losses of the various materials are given in appendix 17.

1953 EXPERIMENT.

Fresh and wilted silages were made from long grass-clover herbage on June 4th and 5th 1953. The official weather forecast on June 4th for S.E. Scotland was: 'wind northerly, moderate,



1.

2.

fresh in exposed places; cloudy or dull with rain or drizzle at times, very cool. Midday temperatures 44-49°F.'

The actual weather experienced on June 4th at Boghall was better than that forecasted; there was no rain or drizzle and the sky was overcast. No rain fell during the night of June 4th and on the morning of the 5th the crop was dry and free from dew. The weather on the 5th was better than that forecast there being no rain or drizzle. There was no wind, the air was cool and the sky overcast. No rain fell during the night of June 4th and on the morning of the 5th the crop was dry and free from dew. The weather on the 5th was better than that forecast there being no rain or drizzle. There was no wind, the air was cool and the sky overcast. During the afternoon, when filling of the silos was near completion, the sky became clear and for the remainder of the day there was continuous sunshine.

Data obtained from Boghall meteorological sub-station on June 5th for air temperature, relative humidity and saturation deficiency are shown in table 25 below:

TABLE 25. METEOROLOGICAL DATA FOR JUNE 5TH - 1953 EXPERIMENT

Date	Time of Day	Wet Bulb °F.	Dry Bulb °F.	Relative Humidity %	Saturation Deficiency m.m./Hg.
June 5th	7.00 a.m.	41	44	78	1.7
" "	9.30 a.m.	43	47	72	2.3
" "	12.00 noon	45	49	73	2.4
" "	3.30 p.m.	48	53	69	3.0

Based on the above figures and on the weather classification worked out from results of previous field trials weather conditions over the two day period were classed as poor.

Information on ensiling dates, number of silos employed and materials ensiled is as follows:

TABLE 26. GENERAL INFORMATION - 1953 EXPERIMENT.

Dates	Silos Filled	Herbage as Ensiled
June 4th	2	fresh
" 5th	2	wilted
" "	2	"
" "	2	"

The field chosen for cutting, situated near the silos, had been sown down under oats in May 1951 with a complex seeds mixture of grasses and clovers at the rate of 38½ lb. per acre. The sward was deliberately cut at an advanced stage of growth and yield was calculated to be 6 tons per acre. Cutting was performed with a mowing

machine to which was fitted a swinging windrower. Although the moisture content of windrowed swathes were not determined and compared with the moisture content of ordinary mown swathes it was doubted whether windrowing caused an increased rate of wilting.

The crop was collected by greencrop loader and one large load of herbage was transported to each pair of silos. Field work was timed as accurately as possible and relevant data on hours of wilting and times of collection are shown in table 27.

TABLE 27. FIELD OPERATIONS - 1953 EXPERIMENT.

Swathes	Crop Treatment	Times of Treatments	
		June 4th	June 5th
F	fresh	collected 3.30 p.m.	
A	wilted 17½ hr.	wilted 3.30 p.m. to	9.00 a.m. and collected
B	" 20 hr.	" 4.20 p.m. to	12.20 p.m. " "
C	" 22½ hr.	" 4.50 p.m. to	3.20 p.m. " "

Sampling.

The swathes allocated for each of the four pairs of silos were sampled immediately after cutting and immediately prior to collection by greencrop loader. Great care was taken to obtain representative samples of the four lots of herbage. This was done by walking along the length of the field in a zig-zag manner and removing small hand samples at frequent intervals from top to bottom

of swathes. The handfuls of herbage were placed into a 4 lb. biscuit tin to give a final bulked sample of approximately 1000 grams. Duplicate bulked samples were taken from each of the four areas, F, A, B, and C.

Table 28 shows that there was close agreement between the moisture content of each pair of samples, the difference between the moisture

TABLE 28. PERCENTAGE MOISTURE CONTENTS OF FRESH AND WILTED SAMPLES OF HERBAGE COLLECTED IN THE FIELD - 1953 EXPERIMENT.

Swathes	Crop Treatment	Bulked Sample 1	Bulked Sample 2	Mean of Samples 1 and 2
F	Fresh	81.67	81.34	81.51
A	wilted $17\frac{1}{2}$ hr.	78.38	78.22	78.30
B	" 20 hr.	76.43	77.07	76.75
C	" $22\frac{1}{2}$ hr.	73.42	72.79	73.11
F - C = overall per cent unit drop in moisture				8.4

content of samples 1 and 2 being less than 1 per cent in each instance. The average figures in the table show that after $17\frac{1}{2}$ hours wilting (commencing at 3.30 p.m.) moisture content had fallen by only 3.2 per cent. units from 81.5 per cent in the F swathes to 78.3 per cent in the B swathes and that the drop increased to 4.8 per cent. units after 20 hours and to 8.4 units after $22\frac{1}{2}$ hours by which time the moisture content had fallen to 73.1 per cent. The dry matter correspondingly

rose from 18.5 per cent. to 26.9 per cent. after 22½ hours wilting.

Filling the silos.

Two silos were each filled with 14 cwt. of unwilted herbage, but due to an underestimation of of the quantity of wilted material required only 12½ cwt. of wilted herbage was available for each of the remaining six silos. The silos were situated near the field so no sampling was carried out during ensilage, the moisture contents obtained from the field samples being considered the same as the moisture contents of the same materials at the time of filling.

Results for chemical analyses are shown in table 29. Figures for crude protein show that the crop was cut at the medium protein stage. The results as a whole show that chemical composition was the same in the fresh and wilted materials.

TABLE 29. CHEMICAL COMPOSITION OF FRESH AND WILTED HERBAGE - 1953 EXPERIMENT.
(dry matter basis)

Material	Crop Treatment	Moisture Content %	Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N-free Extractives % ✱
F	fresh	81.5	18.5	12.9	27.7	8.5	48.9
A	wilted 17½ hr.	78.3	21.7	12.6	28.7	8.3	48.6
B	" 20 hr.	76.8	23.2	12.6	28.5	8.3	48.6
C	" 22½ hr.	73.1	26.9	12.6	28.8	8.1	48.5

✱ N.F.E. calculated by assuming an ether extract of 2 per cent.

The time required to fill one silo was approximately 1½ hours. Maximum thermometers, encased in metal tubes, were inserted into the herbage while filling was in progress. After they were filled the silos were sealed with waterproof paper and covered with 6 inches of soil. Metal lids were placed over each silo to keep out rain.

Soon after completion of ensilage, effluent commenced to flow from the two unwilted silages. Collections were made over a period of weeks, a total of 11 gallons being finally collected from one silo and 11½ gallons from the other. Data on total solids, nitrogen contents, sugar contents and pH values are given in appendix 18. There was no effluent seepage from the wilted silages.

Emptying the silos.

The silos were emptied on March 5th, 1954, and the maximum thermometers extracted from the silage. The average maximum temperature reached in the two F silages was 64°F. (17.8°C.). The corresponding average figures for the A, B and C silages were 65°F. (18.3°C.), 76°F. (24.4°C.) and 80°F. (26.7°C.) respectively. Thus all the silages had undergone the so called 'cold fermentation' process, this probably being due to the smallness of the silos, efficiency of consolidation and rapidity of filling and sealing. The highest

temperatures were recorded in the C silages made from the driest of the herbages.

Mouldy material was found in the top 8 inches of each wilted silage though extensive mould was present in only the first 3 inches. All inedible materials were weighed and found to represent 17 per cent. of the total quantity of A silage, 25 per cent. of B silage and 22 per cent. of C silage. No mould was present in the F silages.

Each silage was sampled in two ways: (a) by extracting five cores, each of 1½" daimeter, from the full depth of material, (b) by removing small handfuls of silage during the course of emptying. Chemical analyses were carried out on the hand samples and table 30 gives details on the composition of each silage.

TABLE 30. CHEMICAL COMPOSITION OF FRESH AND WILTED SILAGES 1953 EXPERIMENT.

(dry matter basis)

Type of Silage	Moisture Content %	Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N-free Extractives % *
F - fresh	83.0	17.0	13.2	32.9	8.9	42.0
"	83.1	16.9	13.4	33.0	9.4	41.2
A - wilted 17½ hr.	80.4	19.6	13.6	32.6	9.3	41.5
" " "	80.4	19.6	13.3	31.7	9.1	42.9
B - wilted 20 hr.	78.4	21.6	13.0	31.7	9.5	42.8
" " "	78.3	21.7	13.5	31.6	9.1	42.8
C - wilted 22½ hr.	76.1	23.9	15.1	30.8	9.9	41.2
" " "	76.3	23.7	13.7	32.8	9.0	41.5

* N.F.E. calculated by assuming an ether extract of 3 per cent.

A comparison of the figures for moisture content in table 30 with those for the field samples in table 29 shows that all the silages were higher in moisture content than the original materials, there being increases of 1.6, 1.9, 1.6 and 3.1 per cent. units of moisture respectively in the F, A, B and C silages. All the silos were waterproof so that the increases in moisture content would be due to the process of fermentation. Whereas the overall difference between the moisture content of the fresh herbage, 81.7 per cent., and the wilted herbage, 73.4 per cent., was 8.4 per cent. units the difference between the fresh silage, 83.1 per cent., and the wilted silage, 76.2 per cent., was only 6.9 per cent. units.

The figures in table 30 show little difference in chemical composition between the fresh and wilted silages with the exception of the high crude protein figure of 15.1 per cent. in one of the C materials, probably caused by an error in sampling.

Quality.

Results for organic acid contents and pH values, obtained from the hand samples, are given in table 31. The figures show that all the silages were well preserved with low contents of butyric acid. There were only small differences in lactic acid content though the content of acetic acid was less in the wilted silages than in the

fresh materials, and least of all in the C silages containing the lowest content of moisture. The pH values were highest in the wilted materials.

Mention was earlier made of samples obtained with the aid of a silage corer. Five cores were extracted from each of the F and C silages and full results for moisture contents, dry matter

TABLE 31. QUALITY OF FRESH AND WILTED SILAGES - 1953 EXPERIMENT.

(determined on the fresh silage)

Type of Silage	Butyric Acid %	Lactic Acid %	Acetic Acid %	pH
F - fresh	-	1.39	0.42	4.0
"	0.03	1.26	0.40	4.0
A - wilted 17½ hr.	0.01	1.19	0.25	4.0
" " "	0.02	-	0.20	4.0
B - wilted 20 hr.	0.02	1.30	0.17	4.3
" " "	-	1.12	0.17	4.3
C - wilted 22½ hr.	0.05	1.28	0.12	4.4
" " "	0.02	1.22	0.14	4.3

contents and pH values are given in appendix 19. Average results are given in table 32 below and it is interesting to compare these with the figures for moisture content, dry matter and pH value in tables 30 and 31. The figures show that pH values of the F silages were lower in the core samples (table 32) than in the hand samples (table 31) but that there was no difference between the pH value of the core and hand samples of wilted silage. The

TABLE 32. MOISTURE AND DRY MATTER CONTENTS AND pH VALUES OF CORE SAMPLES OF FRESH AND WILTED SILAGES - 1953 EXPERIMENT.

(each result is a mean of five determinations)

Type of Silage	Moisture Content %	Dry Matter %	pH
F - fresh	81.9	18.1	3.7
F - "	81.8	18.2	3.8
C - wilted 22½ hr.	76.0	24.0	4.2
C - " " "	75.8	24.2	4.3

moisture content of the F cores (table 32) was 1.2 per cent. units lower than that of the hand samples (table 30) and this would be due to loss of moisture during the coring process. There was negligible difference in moisture content of the core and hand samples of C silage made from wilted material.

Losses.

Effluent.

Effluent seepage from the two F silages resulted in dry matter losses of 2.6 per cent. and 2.8 per cent. respectively the calculations being made on the original amounts of dry matter ensiled. The corresponding losses for crude protein were 4.0 per cent. and 4.5 per cent. respectively. There were no effluent losses with the wilted silages.

Fresh matter.

The figures in table 33 give the total amount of material ensiled and extracted from each silo and the fresh weight losses sustained during the

9 months storage period. With the unwilted silages fresh weight losses were about 10 per cent. whereas the losses of the wilted materials were only about 4 per cent.

TABLE 33. FRESH MATTER LOSSES IN FRESH AND WILTED SILAGES - 1953 EXPERIMENT.

Type of Silage	Herbage Ensiled lb.	Silage Removed lb.	Loss %	
F - fresh	1568	1412	9.9)	10.5
"	1568	1395	11.0)	
A - wilted 17½ hr.	1397	1329	4.9)	3.8
" " "	1397	1359	2.7)	
B - wilted 20 hr.	1377	1268	7.9)	4.8
" " "	1377	1354	1.7)	
C - wilted 22½ hr.	1377	1332	3.3)	3.6
" " "	1377	1324	3.8)	

Dry matter.

Dry matter and nutrient losses were calculated from the results of analyses of the hand samples collected at the times of filling and emptying of the silos. Full results on losses are shown in table 34. The average loss of dry matter in the F silages was 18.0 per cent. and included in this there was an average effluent dry matter loss of 2.7 per cent. Average dry matter loss in the A, B and C silages was only 13.0 per cent. Corrections were made for loss of volatile acids during oven drying. With the type of oven used 80 per cent

TABLE 34. DRY MATTER AND CRUDE NUTRIENT LOSSES OF FRESH AND WILTED SILAGES - 1953 EXPERIMENT.
(dry matter basis)

Type of Silage	Dry Matter %		Corrected dry Matter %		Crude Protein %		Crude Fibre %		Ash %		N-free Extractives %	
F - fresh	17.3		15.3		15.2		1.7		13.4		29.0	
"	18.7		17.1		15.5		3.2		10.1		31.6	
F - AVERAGE	18.0		16.2		15.4		2.5		11.8		30.3	
A - wilted 17½ hr.	14.1)	13.1	13.1)	12.2	9.4)	7.3	4.4)	2.0	6.0)	3.8	24.1)	24.5
" "	12.1)		11.3)		5.2)		0.5)		1.6)		24.9)	
B - wilted 20 hr.	13.9)	11.2	13.6)	10.5	7.7)	6.7	4.5)	1.4	5.7)	0.7	24.1)	21.8
" "	8.5)		7.4)		5.7		1.8)		4.4)		19.4)	
C - wilted 22½ hr.	14.1)	14.7	13.6)	14.2	3.0)	2.5	8.2)	5.9	5.0)	1.2	27.0)	27.3
" "	15.3)		14.8)		7.9)		3.6)		2.7)		27.5)	
A, B & C AVERAGE	13.0		12.3		5.5		3.1		1.1		24.5	

of volatile acids were lost when the over temperature was held at 100°C. Table 34 shows that the average corrected dry matter loss of the F silages was 16.2 per cent., some 2 per cent. units of dry matter less than the uncorrected figure of 18.0 per cent. Unlike the fresh silages the wilted silages contained a small quantity of volatile acids, with the result that there was a difference of only 0.7 per cent. units of dry matter between the average corrected dry matter loss of 12.3 per cent. and the uncorrected figure of 13.0 per cent.

Since no analyses were carried out on the

fresh silages no corrections could be made for loss of volatile bases. All the silages were well preserved, however, so that little loss of volatile bases should have occurred during oven drying.

The average loss of crude protein was much greater in the F silages, 15.4 per cent. compared to the A, B and C silages, 5.5 per cent., and even allowing for the effluent loss of 4.3 per cent. the total loss of this constituent from the fresh silage was twice that of the wilted materials.

Average losses of crude fibre were approximately the same for the fresh and wilted silages. But ash losses were much greater for the fresh silage, 11.8 per cent. compared to only 1.1 per cent. for the wilted material. Losses of nitrogen-free extractives were also greater for the fresh silages, 30.3 per cent. compared to 24.5 per cent. for the wilted material.

Losses of digestible nutrients were obtained for one fresh silage. The loss of digestible dry matter was 16.5 per cent. and that of digestible crude protein, digestible crude fibre, and digestible N-free extractives + 2.6 per cent., + 2.7 per cent. and 30.6 per cent. respectively.

Digestibility trials.

Digestibility trials were carried out on (a) fresh unwilted herbage, (b) one fresh and one

wilted silage . Half-bred wether sheep were used, two for the trial on fresh herbage and four for each trial on silage. The animals were given at least 7 days pre-feeding of the foods to be tested and this was followed by an experimental period lasting 13 days.

TABLE 35. DIGESTIBILITY TRIALS - 1953 EXPERIMENT.

Type of Material	Percentage Digestibility			
	Dry Matter	Crude Protein	Crude Fibre	N-free Extractives
F - fresh herbage	74.8	68.9	76.6	80.1
F - fresh silage	75.5	76.0	80.1	78.2
C - wilted silage	75.3	76.3	79.5	77.3

Table 35 shows that the percentage digestibility of the dry matter was similar for both fresh and wilted silage and that these were similar to the digestibility of the dry matter in the original unwilted material. The fresh and wilted silages were also similar in respect to percentage digestibility of crude protein, crude fibre and N-free extractives though the results for these constituents were different for the unwilted crop.

1954 EXPERIMENT.

Fresh and wilted silages were made from grass-clover herbage on June 1st and 2nd, 1954. Half the herbage was bruised since one object of

the experiment was to test the effect of both a mechanical and wilting treatment.

On May 31st, the day prior to commencing the experiment, the weather was warm and dry. On June 1st the weather was similar to that forecast, it being cool, windy and dry with nine- to ten-tenths stratocumulus. Total sunshine for the day was 0.9 hours. No rain fell on the night of June 1st and on the morning of the 2nd the crop was found to be free of surface moisture. Weather conditions were similar to those of June 1st.

Data obtained from Boghall meteorological sub-station are shown in table 36. It will be noticed that the drying power of the air, denoted

TABLE 36. METEOROLOGICAL INFORMATION FOR JUNE 1st AND 2nd - 1954 EXPERIMENT.

Date	Time of Day	Wet Bulb °F.	Dry Bulb °F.	Relative Humidity %	Saturation Deficiency m.m./Hg.
June 1st	9.00 a.m.	47	49	86	1.4
" "	12.00 noon	49	51	86	1.3
" "	3.00 p.m.	49	52	80	1.9
June 2nd	7.15 a.m.	43	44	92	0.7
" "	11.00 a.m.	48	51	79	1.9

by the figures for saturation deficiency, was low throughout the experimental period. Based on all the above information and on the weather classification drawn up from the results of the field trials

weather conditions throughout the period were classed as poor.

Information on dates of ensilage, number of silos filled and crop treatments are shown in table 37.

TABLE 37. GENERAL INFORMATION - 1954 EXPERIMENT.

Dates of Filling	Silos Filled	Herbage as Ensiled
June 1st	1	fresh bruised
" "	1	fresh mown
" "	1	bruised and wilted 4 hr.
" "	1	bruised and wilted 8 hr.
" "	1	mown and wilted 8 hr.
" 2nd	1	mown and wilted 27 hr.

The field used for silage, situated near the silos, was sown down in 1952 under oats with a two year seeds mixture of grasses and clovers at the rate of 30 lb. per acre.

A portion of the field was divided into two areas. The herbage in one area was bruised with the SHEARMOW forage harvester from which the elevator had been removed, and in the second area a mowing machine was employed, on this occasion without a swinging windrower. Both operations were commenced at the same time. All materials were harvested with the aid of a greencrop loader, one load of each material being transported to its appropriate silo.

Field operations were timed as carefully as possible and relevant data are given in table 38.

TABLE 38. FIELD OPERATIONS - 1954 EXPERIMENT.

Swathes	Crop Treatment	Times of Treatments	
		June 1st	June 2nd
F	fresh bruised	collected 7.45 a.m.	
A	bruised and wilted 4 hr.	wilted 7.00 a.m. to 11.00 a.m.	
B	" " " 8 hr.	" 7.15 a.m. to 3.15 p.m.	
F	fresh mown	collected 8.00 a.m.	
A	mown and wilted 8 hr.	wilted 7.45 a.m. to 3.45 p.m.	
B	" " " 27 hr.	" 8.00 a.m. to	11 a.

Sampling.

Samples were collected from the fresh and wilted swathes in the field and again, a short time later, from the same materials during ensilage. Full results for moisture contents are given in appendix 20. The method of sampling was identical with that for the 1953 experiment except that a greater number of bulked samples were obtained. Results for moisture contents, summarised in table 39, show that with the exception of the fresh mown material moisture contents of the field samples were less and not, as would be expected, greater than that of the samples obtained at the silos. With regard to rates of wilting the results for the field samples show that after 4

TABLE 39. AVERAGE PERCENTAGE MOISTURE CONTENT OF FRESH AND WILTED HERBAGE SAMPLES COLLECTED IN THE FIELD AND AT THE SILO - 1954 EXPERIMENT.

Herbage	Crop Treatment	Field Samples	Samples at Silos
F	fresh bruised	81.1	81.8
A	bruised and wilted 4 hr.	78.2	79.7
B	" " " 8 hr.	75.1	75.6
F - B = an overall per cent unit moisture drop of		6.0	6.2
F	fresh mown	81.1	80.7
A	mown and wilted 8 hr.	75.0	75.1
B	" " " 27 hr.	71.2	71.7
F - B = an overall per cent unit moisture drop of		9.9 and	9.0

hours of wilting the moisture content of the bruised herbage had dropped by 3 per cent. units, from 81.1 per cent. to 78.2 per cent. and that after 8 hours wilting there was an overall moisture drop of 6 per cent. units in bruised material, from 81.1 per cent. to 75.1 per cent. The dry matter content correspondingly rose from 18.9 per cent. in the F. swathes to 24.9 per cent. in the B swathes.

With the mown material there was a moisture drop of 6.1 per cent after 8 hours wilting, from 81.1 per cent. to 75.0 per cent., the same moisture drop as for the bruised herbage wilted for 8 hours. After 27 hours of wilting there was an overall moisture drop in the mown swathes of 9.9 per cent

units, from 81.1 per cent to 71.2 per cent., so that over the whole period the dry matter content rose from 18.9 per cent. to 28.8 per cent.

Filling the silos.

Each silo was filled with approximately 14 cwt. of material. Analysis of the samples obtained at the silos gave the results shown in table 40.

TABLE 40. CHEMICAL COMPOSITION OF FRESH AND WILTED HERBAGE - 1954 EXPERIMENT.

(dry matter basis)

Material Crop Treatment	Moisture Content %	Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N - free Extractives % *
F - fresh bruised	81.8	18.2	11.9	28.1	9.5	48.5
A - bruised and wilted 4 hr.	79.7	20.3	11.8	29.3	9.5	47.4
B - " " 8 hr.	75.6	24.4	11.9	28.6	9.1	48.4
F - fresh mown	80.7	19.3	12.3	29.5	7.8	48.4
A - mown and wilted 8 hr.	75.1	24.9	10.8	29.2	7.3	50.7
B - " " 27 hr.	71.7	28.3	10.5	29.8	7.3	50.4

* N.F.E. calculated by assuming an ether extract of 2 per cent.

The figures for crude protein show that the crop was ensiled at the medium- to low-crude protein stage. The results as a whole confirm those of the 1953 experiment and also the 1953 field trials which showed that the chemical composition of grass wilted for periods up to 24 hours was the same as that of freshly cut grass. It will be noticed that the bruised materials contained

a higher content of ash than the long materials. This would be due to the occurrence of soil contamination during the bruising process.

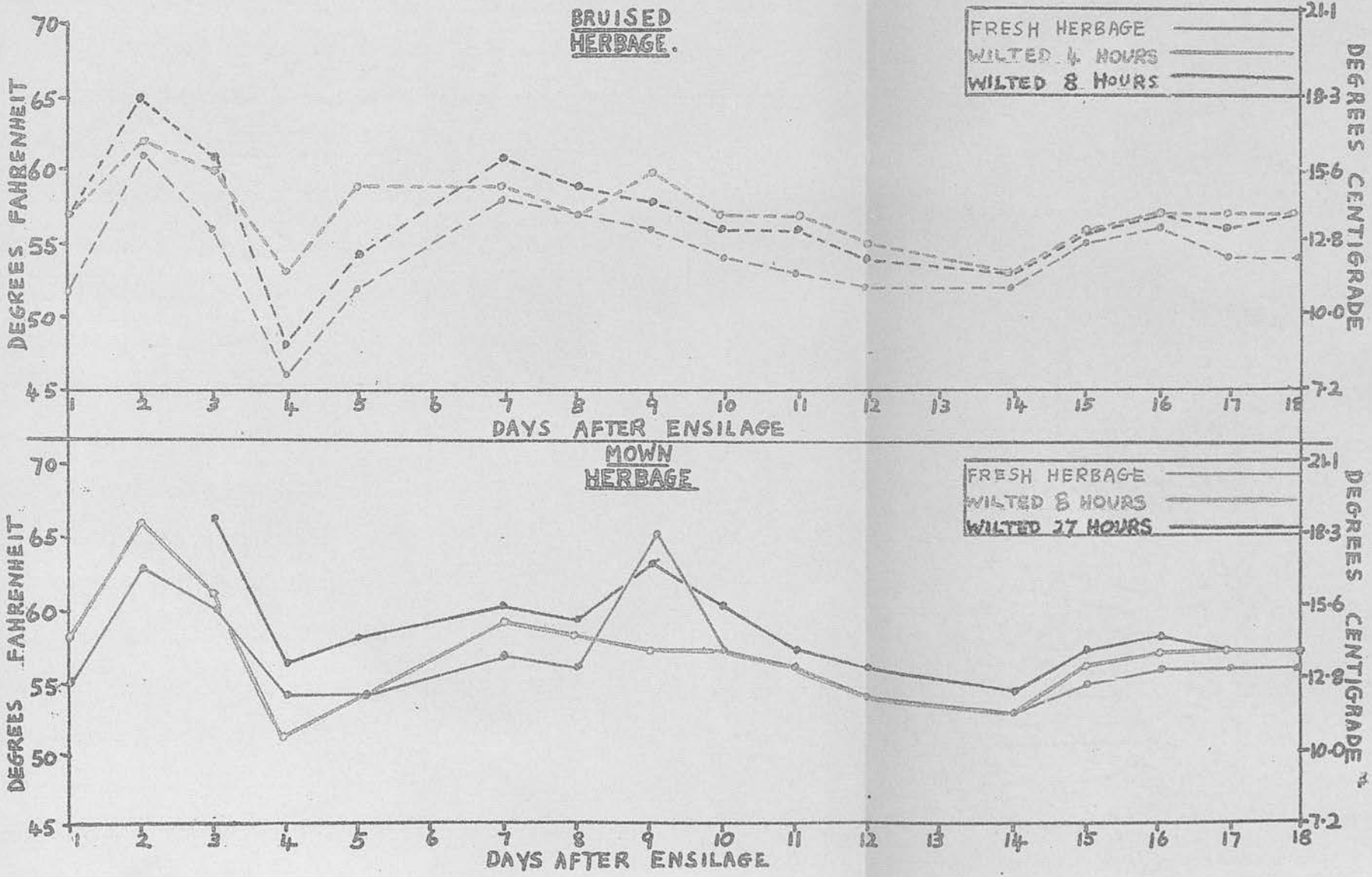
Silage temperatures.

Maximum thermometers were not used for recording silage temperatures since a thermocouple unit, consisting of copper and constantan wires attached to a galvanometer, was now available. Five thermocouples were placed into each silo during the course of filling and temperatures were recorded over a period of $2\frac{1}{2}$ weeks. Full results are given in appendix 21 and the average figures have been used to construct the graph shown on page 171.

It will be observed that temperatures did not rise above 80°F. so that all silages had undergone the so called 'cold fermentation' process. The curves show that after completion of ensilage there was a rapid rise in the temperature of all six silages but that the highest temperature occurred in the wilted materials. Temperatures then declined, the lowest readings being obtained in the more compacted bruised materials. A second though more gradual rise and fall occurred with all six silages before the final readings were taken at the end of $2\frac{1}{2}$ weeks.

In view of the small size of silo employed and hence the possibility of atmospheric temperatures

SILAGE TEMPERATURES-1954



affecting the temperatures within the silos figures for maximum daily air temperature were compared with those for the average temperatures recorded daily from the five thermocouples in each silo. There appeared to be no relationship between the two groups of figures.

On June 4th, three days after filling, effluent began to flow from the fresh silage made from bruised herbage. Samples of effluent were collected over a period of weeks before the effluent pipes were sealed. A total of 10½ gallons of liquid was finally collected, an amount equal to that collected from either of the two fresh silages made from long herbage in 1953. The results in table 40 on page 169 show that the moisture content of the long herbage was similar to that of the bruised material, 81.8 per cent. It would be expected, therefore, that the amount of effluent collected from the long silage would be similar to that collected from the bruised silage, but in fact only 0.5 gallons was obtained. No explanation can be given for the very small quantity collected since the effluent pipe was not blocked and so far as is known the amount of consolidation given at the time of filling was approximately the same for all silos.

Data on total solids, nitrogen contents and pH values of the two effluents are given in

appendix 22. There was no seepage from the wilted silages.

Emptying the silos.

The silos were opened on January 13th and 14th 1955, and their contents sampled by both the core and hand methods. No mould was present in the bruised and long F silages but the top portions of the long silages A and B were mouldy like the 1953 wilted long silages. Of importance is the fact that the top layers of the bruised silages A and B contained only slight traces of mould.

Results of chemical analyses carried out on the hand samples of silage are shown in table 41.

TABLE 41. CHEMICAL COMPOSITION OF FRESH AND WILTED SILAGES - 1954 EXPERIMENT.

(dry matter basis)

Type of Silage	Moisture Content %	Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N-free Extractives % *
F - fresh bruised	82.7	17.3	12.3	31.9	11.7	41.1
A - bruised and wilted 4 hr.	76.9	23.1	13.3	30.9	11.1	41.7
B - " " 8 hr.	77.2	22.8	11.3	29.9	12.1	43.4
F - fresh mown	83.5	16.5	12.3	32.6	8.1	44.0
A - mown and wilted 8 hr.	73.9	26.1	11.9	31.5	8.0	45.6
B - " " 27 hr.	75.1	24.9	12.2	32.4	9.4	43.0

* N.F.E. calculated by assuming an ether extract of 3 per cent.

A comparison of the figures in table 41 with those in table 39 on page 168 shows that the moisture contents of the F and B bruised and long silages were

between 1.6 and 3.9 per cent. units higher than the moisture contents of the herbage samples collected from the field.

Further reference to table 41 shows that the overall difference in moisture content between the fresh bruised silage, 82.7 per cent., and the bruised-8 hour wilted silage, 77.2 per cent., was 5.5 per cent. units compared to the overall difference of 6.0 per cent. units with the corresponding field samples (table 39). Similarly the overall difference in moisture content between the fresh long silage, 83.5 per cent., and the 27 hour wilted long silage, 75.1 per cent., was 8.4 per cent. units compared to the overall difference of 9.9 per cent. units with the field samples.

Results for chemical composition, given in table 41, show little difference between the fresh and wilted silages though, as with the original herbage, the ash content of the bruised material is noticeably higher than that of the long silage. The lower content of N-free extractives in the bruised silages will merely be a reflection of their higher ash content.

Quality.

Results for organic acid contents and pH values of the hand samples of silage, given in table 42 show that all six silages were well preserved. The contents of butyric acid were

TABLE 42. QUALITY OF FRESH AND WILTED SILAGES - 1954 EXPERIMENT.
(determined on the fresh silage)

Type of Silage	Butyric Acid %	Lactic Acid %	Acetic Acid %	pH
F - fresh bruised	-	1.33	0.57	3.9
A - bruised and wilted 4 hr.	-	1.70	0.85	3.8
B - " " " 8 hr.	-	1.74	0.60	4.0
F - fresh mown	-	1.40	0.54	3.8
A - mown and wilted 8 hr.	trace	1.11	0.29	4.4
B - " " " 27 hr.	trace	1.13	0.25	4.3

negligible and of lactic acid, moderately high. The A and B bruised silages contained the highest contents of lactic acid and these two materials also contained the highest content of acetic acid. As with the 1953 experiment, however, the content of acetic acid in the wilted long silage was less than in the fresh long silage. Also, pH values were higher in the wilted long silage than in the fresh long material. On the other hand pH values of the bruised wilted silages were lower and about the same as that of the fresh bruised material.

The five cores extracted from the F and B silages were analysed for moisture content, dry matter content and pH value and full results are given in appendix 23. It is interesting to compare the average results shown in table 43 with the corresponding figures for the hand samples mentioned in the two previous tables.

The pH values were the same but the moisture content of the core samples was lower than that of the hand samples.

It will be remembered that the 1953 field bruising trials showed much greater variations in moisture content in the bruised-wilted swathes

TABLE 43. MOISTURE AND DRY MATTER CONTENTS AND pH VALUES OF CORE SAMPLES OF FRESH AND WILTED SILAGES - 1954 EXPERIMENT.

(each result is a mean of five determinations)

Type of Silage	Moisture Content %	Dry Matter %	pH
F - fresh bruised	81.7	18.3	3.8
B - bruised and wilted 8 hr.	75.7	24.3	3.9
F - fresh mown	81.7	18.3	3.7
B - mown and wilted 27 hr.	74.2	25.8	4.3

than in the mown-wilted swathes and that this was due to the fact that the bruised material settled down on the ground causing a slow rate of wilting in the bottom of the swathe. In the present experiment it was thought advisable to determine whether or not the extreme variations in moisture content of the bruised material would still be noticeable in the subsequent silage.

The five cores extracted from each of the B silages were divided into small sections and moisture determinations carried out on each section Full results, given in appendix 24, show that

there was no greater moisture variation in the bruised-wilted silage than in the mown-wilted material. The reason would be that the upper and lower portions of each swathe would have been thoroughly mixed, during harvesting with the greencrop loader.

Losses.

Effluent.

Effluent seepage from the fresh bruised silage resulted in a dry matter loss of 2.5 per cent. and a crude protein loss of 4.3 per cent. Much less effluent was collected from the fresh long silage and losses of dry matter and crude protein were, therefore, small; 0.14 per cent. and 0.33 per cent. respectively.

Fresh matter.

Table 44 gives figures for the quantities of herbage ensiled and of the silage removed from the silos and also for the fresh weight losses sustained during the 7 months storage period.

TABLE 44. FRESH MATTER LOSSES IN FRESH AND WILTED SILAGES - 1954 EXPERIMENT.

Type of Silage	Herbage Ensiled lb.	Silage Removed lb.	Loss %
F - fresh bruised	1573	1356	13.8
A - bruised and wilted 4 hr.	1567	1470	6.2
B - " " " 8 hr.	1579	1439	8.9
F - fresh mown	1552	1489	4.1
A - mown and wilted 8 hr.	1563	1484	5.1
B - " " " 27 hr.	1478	1451	1.8

Average fresh weight loss of the three bruised silages was 9.6 per cent. and that of the long silages, 3.7 per cent.

Dry matter.

Results for dry matter and nutrient losses are given in table 45. The average dry matter loss of the two F silages was 18.5 per cent. and of the wilted silages, excluding the results for the two A silages which are very doubtful, 14.2 per cent.

TABLE 45. DRY MATTER AND CRUDE NUTRIENT LOSSES OF FRESH AND WILTED SILAGES - 1954 EXPERIMENT.

(dry matter basis)

Type of Silage	Dry Matter %	Corrected Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N-free Extractive %
F - fresh bruised	18.1	15.7	15.2	7.1	0.7	30.6
A - bruised and wilted 4 hr.	6.8	10.0	20.7	12.6	24.8	6.1
B - " " 8 hr.	14.8	13.0	19.2	11.0	14.0	23.3
F - fresh mown	18.0	16.0	17.9	9.4	15.0	25.4
A - mown and wilted 8 hr.	0.5	0.3	9.8	7.4	9.2	10.5
B - " " 27 hr.	13.6	12.9	0.5	6.1	11.5	26.3
F - AVERAGES	18.5	15.9	16.6	8.3	7.2	28.0
B - AVERAGES*	14.2	13.0	9.4	8.6	1.3	24.8

* Results for the two A silages have been excluded.

Corrections for loss of volatile acids during oven drying had the greatest effect with the F silages since these contained the greatest quantity of volatile acid, the average corrected dry matter

loss of the F silages being 15.9 per cent. compared to the uncorrected figure of 18.5 per cent., a difference of 2.6 per cent. units of dry matter. With the wilted silages, again excluding the A silages, the corrected dry matter loss was 13.0 per cent., only 1.2 per cent. units less than the uncorrected figure of 14.2 per cent.

The loss of crude protein was less in the F bruised than in the B bruised silage though the high figure of 19.2 per cent. for the latter will probably be a reflection of the gain in ash content, + 14.0 per cent.

The only other figures worth noting are those for N-free extractives, the average loss of this constituent being 28.0 per cent. for the F silages and 24.8 per cent. for the wilted materials.

Digestibility trials.

Digestibility trials were carried out on (a) the original fresh mown herbage, (b) the fresh bruised silage and the bruised-8 hour wilted silage. The results for percentage digestibility of the various constituents are given in table 46.

Comparing the figures for the bruised-wilted silage with those for the fresh mown grass it appears that the two materials were similar in digestibility. It is doubtful if any significance can be attached to the small difference in the results for crude protein. Digestibility of the

TABLE 46. DIGESTIBILITY TRIALS - 1954 EXPERIMENT.

Type of Material	Percentage Digestibility			
	Dry Matter	Crude Protein	Crude Fibre	N-free Extractives
F - grass - fresh mown	74.3	63.6	76.8	79.9
F - silage - fresh bruised	69.1	58.6	82.6	75.3
B - silage - bruised and wilted 8 hr.	76.4	67.2	87.0	79.5

crude fibre in the wilted silage was apparently higher than that of the original grass but in view of the variability of this fraction it is impossible to say whether a gain had in fact taken place in the wilted material.

No reason can be given for the apparent lower digestibility of the fresh bruised silage compared to either the bruised wilted silage or the fresh mown grass.

1955 EXPERIMENT.

On May 31st and June 1st, 1955, fresh and wilted silages were made from long grass-clover herbage, a proportion of which received the additional treatment of preservative.

The official weather forecast on May 31st for S.E. Scotland was: 'light or moderate S.E. winds; long sunny periods, some cloud or fog, especially near the east coast at first, clearing during morning except for a few patches along east coast; rather cool on east coast, rather warm inland, midday temperatures 50°F. to 55°F. on east coast but 57°F. to 63°F. inland.' Similar weather conditions were forecast for June 1st. The actual weather experienced at Boghall Farm was similar to that forecasted.

Information collected from Boghall meteorological sub-station showed that daily sunshine amounted to 13.6 hours on May 31st. and 12.4 hours on June 1st. Other information obtained from the sub-station is given in table 47. Taking all the weather conditions into consideration and comparing them with the classification drawn up from the results of the previous field trials it is clear that weather conditions during the experimental period were best classed as good.

TABLE 47. METEOROLOGICAL DATA FOR MAY 31st AND JUNE 1st - 1955 EXPERIMENT.

Date	Time of Day	Wet Bulb °F.	Dry Bulb °F.	Relative Humidity %	Saturation Deficiency mm/Hg.
May 31st	7.30 a.m.	46	52	63	3.4
" "	10.30 a.m.	53	65	44	7.8
" "	1.30 p.m.	54	66	44	8.1
June 1st	7.30 a.m.	44	44	100	0.0
" "	10.30 a.m.	48	51	81	1.9
" "	1.30 p.m.	50	54	76	2.4

Information on ensiling dates, number of silos, materials ensiled and preservatives used are given in table 48.

TABLE 48. GENERAL INFORMATION - 1955 EXPERIMENT.

Dates of Filling	Silos Filled	Herbage as Ensiled	Preservative Treatment
May 31st	1	fresh	no addition
" "	1	"	molasses
" "	1	"	metabisulphite
June 1st	1	wilted 18½ hr.	no addition
" "	1	" " "	molasses
" "	1	" " "	metabisulphite

The field chosen for silage, situated about ¼ mile from the silos, had been sown down under barley in 1954 with a 3-year complex seeds mixture of grasses and clovers at 32½ lb. per acre. Since it was intended to introduce the additional

treatment of preservative the crop was cut at an earlier than normal stage of growth. At the time of cutting the sward was leafy and contained a considerable quantity of clover, but also present was straw stubble left from the 1954 cereal crop. Sward yield was calculated to be 3 tons per acre.

Two adjacent areas of the field were cut on May 31st, one for immediate harvesting and the other for ensiling in a wilted condition on June 1st. Times of cutting and collection are given in table 49.

TABLE 49. FIELD OPERATIONS - 1955 EXPERIMENT.

Crop Treatment	Date	
	May 31st	June 1st
fresh	cut 7.15 - 8.35 a.m. collected 7.45 - 9.30 a.m.	
wilted 18½ hr.	cut 1 - 3 p.m.	collected 7.25 - 9.35a.m.

Filling the silos.

As already noted in table 48 two silages were made without preservative, two with molasses and two with sodium metabisulphite. The molasses, diluted with an equal quantity of water to aid distribution, was applied at the rate of 25 lb. per ton of green crop. The metabisulphite was used in powder form at the rate of 12 lb. per ton

of green crop.

Each silo was filled with 14-15 cwt. of herbage and sampling was carried out at the time of filling the silos. In this experiment no samples were collected from the swathes in the field.

Chemical analyses were carried out on the ingoing materials and the results are given in table 50.

TABLE 50. CHEMICAL COMPOSITION OF FRESH AND WILTED HERBAGE - 1955 EXPERIMENT.

(N = no addition, M = molasses and Meta = metabisulphite)

Crop Treatment	Moisture Content %	Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N-free Extractives % *
fresh - N	79.6	20.4	15.1	19.7	9.1	54.1
" - M	79.3	20.7	14.7	18.9	8.7	55.7
" - Meta	78.3	21.7	14.9	20.0	9.1	54.0
AVERAGES	79.1	20.9	14.9	19.5	9.0	54.6
wilted 18½ hr. - N	71.1	28.9	11.8	22.2	7.9	56.1
" " " - M	70.8	29.2	13.0	22.0	8.7	54.3
" " " - Meta	68.2	31.8	11.8	21.6	8.3	56.3
AVERAGES	70.0	30.0	12.2	21.9	8.3	55.6

* N.F.E. calculated by assuming an ether extract of 2 per cent.

The figures for moisture content are interesting in that they confirm the results of the previous field trials which showed the extent to which diurnal variation occurs in the moisture content of a standing crop. The table shows that the fresh material ensiled without preservative con-

tained a moisture content of 79.6 per cent. It was noticed that the herbage was still wet with dew when the samples were collected during mid-morning on May 31st. The second load of fresh material, treated with molasses, was not ensiled until late morning by which time the moisture content had fallen to 79.3 per cent. The final load of herbage, allocated to receive metabisulphite, was quite free from surface moisture when ensiled during early- to mid-afternoon, the moisture content being 78.3 per cent. Thus over a period of 8 hours there was a drop of 1.3 per cent units of moisture in the fresh crop.

Evaporation of surface moisture also occurred with the three lots of wilted material ensiled on June 1st. The first load of wilted herbage was very wet with dew and table 50 shows that at the time of filling it contained a moisture content of 71.1 per cent. But the herbage in the second load contained less free moisture, the moisture content being 70.8 per cent. The final load contained only 68.2 per cent moisture and was dry to the touch. With the wilted material, therefore, there was a moisture drop of 2.9 per cent. units during a period of 8 hours.

Further reference to table 50 shows that a waiting period of 18½ hours (extending from early- to mid-afternoon of May 31st to early- to mid-

morning of June 1st) caused an average overall moisture drop of 9.1 per cent units, i.e. from 79.1 per cent. to 70.0 per cent. The dry matter correspondingly rose from 20.9 per cent. to 30.0 per cent.

As regards chemical composition the results given in the table show that the wilted herbages were very similar to the fresh herbages, with the exception of the crude protein fraction which was lower in the wilted material. In the light of previous results it is assumed that the lower crude protein figures did not result from the effect of wilting. A probable explanation is that the area of herbage allocated for wilting happened to be lower in protein content than that of the adjacent area.

It was mentioned earlier that the crop was leafy and rich in clover, but the figures for crude protein content suggest that medium- to low-crude protein material was harvested. It is possible that the straw stubble acted as a protein diluent.

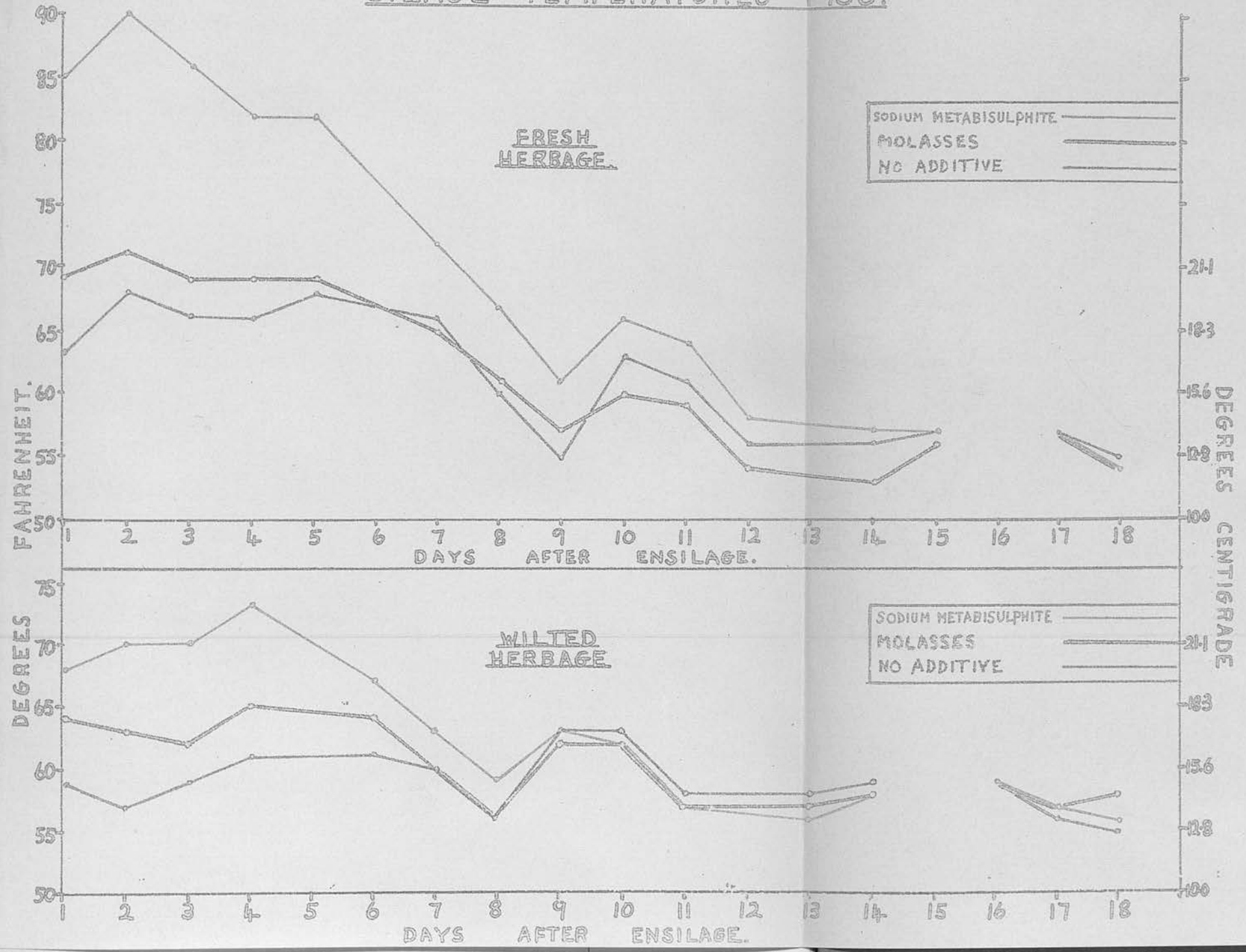
Silage temperatures.

Thermocouples were inserted in the herbage during ensilage and temperatures were recorded over a period of 2½ weeks. Full results for temperature readings are given in appendix 25 and the daily average figures have been used to construct the curves shown in the graph on page 188.

It will be noticed that the three curves for the fresh silages were very different from one another, particularly during the first week, as also were the corresponding curves for the three wilted materials. A comparison of the curves for the fresh silages with the figures for percentage moisture content of the fresh materials at the time of filling, given in table 50 on page 184 , indicates that a relationship might have existed between moisture content and temperature of the ensiled materials. It will be seen that the second load of herbage with 79.3 per cent. moisture rose to a higher temperature than the first load containing 79.6 per cent. moisture and, likewise, that the third load of herbage with 78.3 per cent. moisture reached a higher temperature than the second load of ensiled material. The results of moisture contents and temperatures of the wilted materials show a similar relationship.

It is very doubtful, however, whether such small differences in moisture content would be the cause of the marked differences in temperature of the silages. Further reference to the graph shows that the two silages made with metabisulphite rose to a higher temperature than the two molassed silages and, likewise, the two molassed silages rose to a higher temperature than the two silages made without preservative. Again, it is most

SILAGE TEMPERATURES - 1955.



unlikely that the temperatures attained in the silos were related to the type of preservative used.

A much more probable answer is that the level of temperature was related to the temperature of the herbage at the time of filling, for the following reason. The figures in table 47 on page 182 show that May 31st was a warm day, the dry bulb readings rising from 52°F. at 7.30 a.m. to 65°F. at 10.30 a.m. and to 66°F. at 1.30 p.m. It was on this day that the three loads of fresh material were ensiled, in the order of no addition, molasses and metabisulphite treatments. All three loads were collected after cutting during the morning and then unloaded at the silos. There was a delay of some hours before the second and third loads were ensiled with the result that temperature within the mass increased, even though the loads were protected from the sun by tarpaulins. The highest temperature, of course, occurred in the final load as shown by the starting point of the appropriate curve in the graph, i.e. 85°F.

During June 1st air temperatures were much lower than those of May 31st, the dry bulb readings only reaching 44°F. at 7.30 a.m., 51°F. at 10.30 a.m. and 54°F. at 1.30 p.m. (table 47). The cool air conditions will explain the reason why temperatures of the three wilted silages were

lower than those of the silages made from fresh material.

It should be mentioned that during the period of recording silage temperatures, atmospheric temperatures fluctuated to a much greater extent than during the 1954 period of recording. Figures for maximum daily air temperature were, therefore, again compared with those for the average temperatures recorded daily from each group of five thermocouples. On this occasion there did appear to be some slight relationship between the two groups of figures but, apparently, only on those days when sudden changes occurred in the temperature of the atmosphere. It is very probable that a more definite relationship would have been noticed had it been known which of the figures from each group of five temperature readings were obtained from the thermocouples situated nearest the walls of the silos.

On June 2nd effluent began to flow from all three silos containing fresh material. A total of approximately 11 gallons was finally collected from the untreated and molassed silages but only 5 gallons from the metabisulphite silage. Data on total solids, nitrogen contents and pH values are given in appendix 26. There was no drainage of effluent from the wilted silages.

Emptying the silos.

The silos were emptied on January 9th and 10th 1956 and samples taken both by the corer and hand methods. Visual inspection did not show any marked difference between the three fresh silages, nor between the three wilted silages, though the wilted silage preserved with metabisulphite was darker than the corresponding fresh silage.

Mouldy material was present in the top of all three silos containing wilted silage and, in contrast to the 1953 and 1954 silages, mould was also present in the fresh materials, amounting to 6 per cent., 7 per cent. and 5 per cent. respectively of the total quantity of untreated, molassed and metabisulphite treated materials compared to 7 per cent., 9 per cent. and 12 per cent. in the corresponding wilted silages.

Chemical analysis was carried out on the hand samples and the results are given in table 51.

TABLE 51. CHEMICAL COMPOSITION OF FRESH AND WILTED SILAGES - 1955 EXPERIMENT.

(N = no addition, M = molasses and Meta = metabisulphite)

	Moisture Content %	Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N-free Extractives % *
fresh - N	81.2	18.8	16.2	22.9	10.0	47.9
" - M	80.1	19.9	16.6	22.1	10.3	48.0
" - Meta	79.9	20.1	17.6	21.6	12.0	45.8
AVERAGES	80.4	19.6	16.8	22.2	10.8	47.2
wilted 18½ hr. - N	75.7	24.3	14.3	22.9	9.8	49.7
" " " - M	73.4	26.6	13.6	23.7	9.5	50.2
" " " - Meta	71.5	28.5	14.6	22.0	10.3	50.1
AVERAGES	73.5	26.5	14.2	22.9	9.9	50.0

* N.F.E. calculated by assuming an ether extract of 3 per cent.

A comparison of the figures for moisture content in table 51 with the corresponding moisture content figures in table 50 on page 184 shows that all the silages were more moist than the same material at the time of ensilage. The moisture increases ranged from 0.8 to 1.6 per cent. units in the fresh silages and from 2.6 to 4.6 per cent. units in the wilted silages. Thus, whereas the overall difference in moisture content of the fresh and wilted herbages was 9.9 per cent. units (table 50) the difference in moisture content between the fresh and wilted silages was less, only 6.9 per cent. units (table 51).

Further reference to table 51 shows that there was negligible difference in chemical composition between the fresh and wilted silages,

with the exception of the crude protein fraction which, as previously mentioned, was higher in the unwilted materials.

Quality

Results for organic acid contents, obtained from analyses of the core samples, are given in table 52. The results show that butyric acid contents were low in all except the two silages made with metabisulphite, i.e. 0.31 per cent. and 0.23 per cent. respectively. These two silages, however, possessed no odour of butyric acid and the analytical evidence indicated that the high figures were due to the presence of sulphur in the preservative, and not to butyric acid.

Based on the content of lactic acid all the silages were well preserved though the content of this acid was slightly less in the wilted than in the unwilted materials, and least of all in the metabisulphite treated materials. Likewise acetic acid contents were lower in the wilted silages and least of all in the two metabisulphite materials. Values for pH were low in all silages except those preserved with metabisulphite, 4.6 and 5.0 respectively for the fresh and wilted materials. As with the previous experiments pH values were slightly less with the core samples than with the hand

TABLE 52. QUALITY OF FRESH AND WILTED SILAGES - 1955 EXPERIMENT.
(determined on the fresh silage)

Type of Silage	Butyric Acid %	Lactic Acid %	Acetic Acid %	pH Hand Samples	pH Core Samples
fresh - N	0.0	2.56	0.32	4.1	3.9
" - M	0.04	2.38	0.36	3.9	3.9
" - Meta	0.31	1.45	0.08	4.6	4.3
AVERAGES	0.12	2.13	0.25	4.2	4.0
wilted 18½ hr. - N	0.03	2.22	0.26	4.0	4.1
" " " - M	0.03	2.12	0.24	4.1	4.1
" " " - Meta	0.23	1.65	0.02	5.0	4.8
AVERAGES	0.97	2.00	0.17	4.4	4.3

samples and particularly so in the case of the metabisulphite silages.

Losses.

Effluent.

Effluent seepage resulted in dry matter losses of 2.5 per cent., 3.4 per cent. and 0.6 per cent. respectively for the untreated, molassed and metabisulphite fresh silages. The corresponding crude protein losses were 4.4 per cent., 4.2 per cent., and 0.5 per cent. respectively.

Fresh matter.

The result given in table 53 show the quantities of herbage ensiled and extracted and the fresh losses sustained during storage. Losses of the wilted silages were again much less than in the fresh silages, averaging 3.9 per cent and 10.5 per cent respectively.

TABLE 53. FRESH MATTER LOSSES IN FRESH AND WILTED SILAGES - 1955 EXPERIMENT.

(N = no addition, M = molasses and Meta = metabisulphite)

Type of Silage	Herbage Ensiled lb.	Silage Removed lb.	Loss %
fresh - N	1680	1426	15.1
" - M	1714	1521	11.3
" - Meta	1689	1554	8.0
AVERAGE			10.5
wilted 18½ hr. - N	1604	1550	3.4
" " " - M	1714	1635	4.6
" " " - Meta	1689	1624	3.8
AVERAGE			3.9

Dry matter.

Results for dry matter and nutrient losses are given in table 54. As in the previous experiments the dry matter loss of the wilted silage made without preservatives was less than the loss of the untreated fresh silage, though in this case the difference of 3.1 per cent. in the loss figures (21.8 per cent. minus 18.7 per cent.) was almost accounted for by the effluent dry matter loss of the fresh silage, 2.5 per cent.

If the average dry matter loss of 20.3 per cent. for the fresh N silage (21.8 per cent.) and the wilted N silage (18.7 per cent.) is compared with the average loss figure of 14.1 per cent. for the two M and two Meta silages than it is clear that the addition of preservative had the

TABLE 54. DRY MATTER AND CRUDE NUTRIENT LOSSES OF FRESH AND WILTED SILAGES - 1955 EXPERIMENT.

(dry matter basis)

Type of Silage	Dry Matter %	Corrected Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N-free Extractives %
fresh - N	21.8	20.5	16.1	9.0	14.1	30.7
" - M	14.7	13.4	3.8	0.3	1.0	26.5
" - Meta	14.8	13.5	0.7	7.9	12.3	27.7
AVERAGES	17.1	15.8				28.3
wilted 18½ hr. - N	18.7	18.1	0.5	16.1	0.8	28.0
" " " - M	13.1	12.4	9.2	6.4	5.1	19.7
" " " - Meta	13.8	13.2	6.6	12.2	7.0	23.3
AVERAGES	15.2	14.6				23.7

effect of reducing dry matter loss by approximately 30 per cent. compared to silage given no preservative treatment.

Of particular interest is the fact that dry matter losses of the materials which had received both wilting and preservative treatments were about the same as the dry matter losses of the fresh materials given the single treatment of preservative. From this it is assumed that little advantage is gained by adding preservatives to partially wilted grass-clover herbage of medium to low-protein content. Another point of interest is that the dry matter loss of the fresh silage preserved with molasses, 14.7 per cent., was the same as that of the metabisulphite silage, 14.8 per cent. Likewise the dry matter losses of the

wilted M and wilted Meta silages were similar, 13.1 per cent. and 13.8 per cent. respectively.

The losses of crude protein, crude fibre and ash were extremely variable. The figures for N-free extractives, however, suggest that the loss of this constituent was less with the silages made by the double treatment of wilting and preservative than with the materials which had been given the single preservative treatment.

Dry matter corrections were again greatest with the fresh silages which contained the largest amounts of volatile acids. The figures for the fresh silages show an average corrected dry matter loss of 15.8 per cent., 1.3 per cent. units less than the uncorrected dry matter loss 17.1 per cent. The difference between the corrected and uncorrected dry matter losses of the wilted silages was only 0.6 per cent. units.

COMBINED RESULTS.

The most important results obtained from the 1953, 1954 and 1955 experiments have been grouped together in the following two tables.

Average results for moisture contents and dry matter contents, given in table 55, show that partial wilting caused an overall moisture drop of 6.4 per cent. units, from 80.4 per cent.

TABLE 55. AVERAGE MOISTURE AND DRY MATTER CONTENTS OF FRESH AND WILTED GRASS-CLOVER HERBAGE AND OF THE RESULTING SILAGES - 1953, 1954 and 1955 EXPERIMENTS.

Constituent %	Grass-Clover			
	In the Field		In the Silos	
	fresh	wilted	fresh	wilted
moisture ,	80.4	74.0	81.9	76.6
dry matter	19.6	26.0	18.1	23.4

in the fresh herbage to 74.0 per cent. in the wilted herbage. Dry matter contents correspondingly rose from 19.6 per cent. to 26.0 per cent. During storage, however, the unwilted materials increased in moisture content by 1.5 per cent. units, from 80.4 per cent. to 81.9 per cent., and the wilted materials by 2.6 per cent. units from 74.0 per cent. to 76.6 per cent. Each silo was properly protected from rain so it is assumed that these moisture increases were due to fermentation processes in the silage.

Average results for quality and losses of the fresh and wilted silages are given in table 56. It should be pointed out that included

TABLE 56. AVERAGE RESULTS OF QUALITY AND LOSSES OF FRESH AND WILTED SILAGES - 1953, 1954 and 1955 EXPERIMENTS.

(organic acids determined on fresh matter, nutrient losses on dry matter)

Constituent	Type of Silage Fresh	Wilted	Constituent	Type of Silage Fresh	Wilted
	Quality			Total Losses	
Butyric acid %	0.06	0.05	wet matter %	10.5	4.3
lactic acid %	1.68	1.49	dry matter %	17.6	13.8
acetic acid %	0.38	0.22	corrected dry matter %	15.9	13.1
pH value	4.0	4.2	crude protein %	11.9	4.9
	Effluent losses		crude fibre %	5.5	6.4
			ash %	5.5	1.7
dry matter %	2.1	0.0	N-free extractives %	28.8	22.4
crude protein %	3.2	0.0			

in the average results are those for the silages which had also received a bruising or preservative treatment.

The figures for organic acids show that all the silages were well preserved since they contained low contents of butyric acid and relatively high contents of lactic acid. Compared to the fresh silages, however, the wilted materials were lower in lactic and acetic acid contents and slightly higher in pH values.

Total fresh weight losses of the wilted silages averaged 4.3 per cent., 60 per cent. less than the average fresh loss of the unwilted

silages, 10.5 per cent. Average dry matter loss of the wilted silages was 13.8 per cent., 20 per cent. less than that of the fresh silages with an average loss of 17.6 per cent. The difference between the average dry matter losses of the fresh and wilted materials was only partly accounted for by the effluent dry matter loss of 2.1 per cent.

When corrections were made for loss of volatile acids in the oven it was found that the dry matter loss of the wilted silages was 18 per cent. less than that of the fresh silages, compared to the above-mentioned figure of 20 per cent. on an uncorrected basis.

Crude protein losses were approximately 60 per cent. less for the wilted than for the fresh silages though the effluent crude protein loss of 3.2 per cent. only accounted for a small part of the difference in crude protein loss of the fresh silages, 11.9 per cent., and the wilted silages, 4.9 per cent.

Finally, the N-free extractives loss of 22.4 per cent. for the wilted silages was over 20 per cent. less than the loss of this constituent in the fresh silages, 28.8 per cent.

DISCUSSION

The results of silage experiments, using small experimental silos, largely agree with those of numerous investigations carried out in other countries on fresh and wilted herbage which showed that, except in special circumstances, moisture content is a vital factor in the changes which subsequently take place during the storage period (see page 27). The Edinburgh experiments were deliberately confined to the making of silages containing the upper levels of moisture, 70-80 per cent, since the ultimate object of the investigation was to make corresponding farm silages in trench silos which, unlike large upright silos, do not permit satisfactory storage of herbage containing low moisture levels.

No bacterial analyses were carried out but it was clear from the results of chemical analyses that fermentation had proceeded less vigorously in herbage submitted to partial wilting than in material of higher moisture content, which agrees with the results of other studies including those conducted at Reading.

The majority of investigators maintain that pH value is higher in wilted than in unwilted silage and, therefore, that pH value is not a satisfactory guide to quality of wilted silage (see page 31). The results obtained at

Edinburgh substantiate these findings, though, presumably due to the mild degree of wilting given, pH values were not very much higher in the wilted products. Of particular interest is the fact that the wilted silage made from bruised material was as low in pH value as the fresh long and fresh bruised silage.

Since all the silages were well preserved it was not possible to confirm the point on which there is most agreement, namely that butyric acid production is markedly reduced in the silages made from wilted material (see page 33).

Data obtained on lactic acid contents did not confirm the results of the majority of experiments carried out at other centres which indicated that the content of this acid is greater in wilted than in fresh silage (see page 34). The wilted silages made at Edinburgh were consistently slightly lower in lactic acid content than were the unwilted materials, with the exception of the wilted silage made from bruised herbage which contained a higher lactic acid content than any of the other silages. The consistently marked lower contents of acetic acid in the wilted products supports the results obtained by some investigators, including those at Reading (see page 35). Again, however, there was one exception, i.e. the wilted silages

made from bruised herbage which contained acetic acid contents slightly higher than any of the other silages.

Effluent seepage never occurred with the wilted silages containing an average moisture content of 74 per cent., which closely corresponds with the findings of other investigators who determined the range of silage moisture contents at which effluent flow is likely to cease (see page 40). It is entirely agreed that losses due to formation of mould are likely to be much higher in wilted silage (see page 41). As much as 17 to 25 per cent. of mouldy material was found in the 1953 wilted silages which demonstrated the fact that even partially wilted herbage requires much more consolidation than unwilted material. The superiority of the wilted silage made from bruised herbage was again apparent, the amount of mouldy material being negligible in these silages.

The results of most interest are those for the losses of dry matter, an average of 17.6 per cent. in fresh silage and 13.8 per cent. in wilted silage, which closely correspond to the average figures calculated from the results of numerous experiments conducted in other countries, 16.6 per cent. and 13.4 per cent. respectively for fresh and wilted silage (see page 43).

The writer agrees with the many workers who maintain that some form of mechanical treatment is desirable when using wilted herbage, not only for the purpose of preventing mould formation (see pages 41-2) but also for suppressing temperature and maintaining protein digestibility (see pages 37-8). Up to the present most centres have experimented with chopped herbage and not, as at Edinburgh, with bruised material. (As will be seen later, in Section 4, mechanical treatment is not absolutely essential for herbage wilted to an average moisture content of 70 per cent., provided prolonged consolidation is allowed.)

Finally, the results for the silages made with preservatives (molasses or metabisulphite) support the data obtained at other centres which indicated that the real value of a preservative, measured in terms of dry matter loss of silage, is only to be obtained with fresh herbage and that little advantage is to be gained by adding preservatives to wilted material since total nutrient losses will in any case be markedly reduced as a result of the single treatment of wilting (see pages 43 and 47-9).

If wilted herbage must receive an additional treatment then it would seem that the advantage lies in favour of a mechanical rather than a preservative treatment, for the reasons already

stated. Moreover, the author holds the opinion that the treble treatment of wilting + mechanical + preservative is probably uneconomic, except perhaps for high protein herbage which is not yet made extensively into silage in this country.

SUMMARY AND CONCLUSIONS

1. During 1953, 1954 and 1955 twenty silages were made from fresh and partially wilted grass-clover herbage of medium- to low-protein content, all in experimental concrete silos of 15 cwt. capacity. Most of the silages were made from long herbage.
2. No rain fell at the time of filling the silos. Weather conditions were classed as poor during the making of the 1953 and 1954 silages and good during the 1955 experiment. Wilting was carried out for periods of up to about 24 hours and during such weather conditions moisture contents dropped from 80.4 per cent. to 74.0 per cent., an average drop of 6.4 per cent. units.
3. Herbage bruised by the SHEARMOW forage harvester and allowed to fall on the ground in the form of swathes lost moisture at the same rate as mown swathes, which confirmed results of previous field trials carried out to compare the rate of wilting in bruised and mown materials.
4. Although the upper portions of bruised swathes dried out much more rapidly, and the lower portions more slowly, than the corresponding portions of mown swathes the

subsequent bruised-wilted silage was no more variable in moisture content than the silage made from wilted long material, the reason being that the upper and lower portions of all swathes were thoroughly mixed during the operation of harvesting with a greencrop loader.

5. Extensive mould was present in the upper layers of silage made from partially wilted long herbage containing moisture contents not lower than the 70 per cent. level. Negligible mould was present in either the fresh or wilted silage made from bruised herbage which was easy to consolidate in the silo.

6. Edible portions of all silages were satisfactorily preserved. Butyric acid contents were low and lactic acid contents relatively high. Compared to the fresh silages the wilted silages were similar in butyric acid content, lower in lactic acid content, appreciably lower in acetic acid content and slightly higher in pH value. The bruised-wilted silages were particularly high in lactic acid content and, compared to the wilted silages made from long herbage, were lower in pH value.

7. During storage all silages increased in

moisture content by approximately 2 per cent. units, the increase being attributed to fermentation processes and not to entry of rain into the silos.

8. No effluent was lost from the wilted silages but effluent from the fresh silages accounted for a dry matter loss of 2 per cent. of the total quantity of dry matter ensiled.

9. Total fresh weight losses for the unwilted silages averaged 10.5 per cent., compared to 4.3 per cent. for the wilted silages. Average nutrient losses for the fresh and wilted silages, including the silages which had received an additional bruising or preservative treatment, were for dry matter, 17.6 per cent. and 13.8 per cent.; for corrected dry matter, 15.9 per cent. and 13.1 per cent.; for crude protein, 11.9 per cent. and 4.9 per cent. and for N-free extractives, 28.8 per cent. and 22.4 per cent. respectively. The above silo losses are assumed to be <u>total</u> losses since the field trials' results indicated that field losses were negligible during wilting periods of up to 24 hours.

10. Dry matter losses of fresh and wilted silages made from bruised material were similar to the dry matter losses of

corresponding silages made from long material.

11. Dry matter losses of the silages made from herbage containing 70-80 per cent. moisture, carefully treated with molasses and meta-bisulphite, averaged 14.1 per cent., approximately 30 per cent. less than the dry matter loss of 20.3 per cent. for silages made from material of similar moisture level and not treated with preservative.

12. Metabisulphite appeared to be no better a preservative than molasses for either fresh or partially wilted herbage, this conclusion being based on the quality and losses of the various silages.

13. Since the dry matter losses of the two silages produced from herbage given the double treatment of wilting + preservative were very similar to the losses of the two unwilted silages given the single treatment of preservative it is concluded that applications of preservative to partially wilted grass-clover herbage of medium- to low-protein content are not necessary.

14. The treble treatment of wilting + bruising + preservative was not tried since this is considered to be an uneconomic method.

15. Digestibility trials showed that silage made

from partially wilted herbage was not lower in digestibility than silage made from fresh material.

SECTION 4.

FARM SILAGES

The results given in Sections 2 and 3 clearly indicate that partial wilting is a method which can be practised satisfactorily under all except 'very poor' weather conditions and that losses in silage made from partially wilted material are less than in silage of normal moisture content. Since the trials were carried out on a small scale, however, it was not possible to obtain information of most importance to the farmer, namely the practical problems connected with the harvesting and ensiling of large quantities of wilted herbage, using ordinary farm methods. Hence it was necessary to carry on the investigation to a third stage, i.e. the cutting and wilting of a relatively large acreage of grass and clover and ensiling it in trench silos instead of small experimental silos. The silages were made on the farms of the Edinburgh School of Agriculture during summer 1955 and the results are given in this section.

MATERIALS AND METHODS.

Four trench silages were made during June and July 1955 from grass and clover crops of medium-to low-crude protein content. Yields were estimated at 4 to 5 tons per acre. As a whole the season was exceptionally warm so that much of the herbage was dry and stemmy at the time of cutting. This is indicated by the low average moisture content of the freshly cut herbage, 76.6 per cent. The fact that weather conditions were 'very good' during part of the ensiling period was fortunate, not because the moisture content of the freshly cut herbage would readily fall to the desired level of 70 per cent., but because an opportunity arose for determining the greatest extent to which moderate-yielding, stemmy crops, submitted to partial wilting, would become overheated in an efficiently filled silo.

Two silages were made in ordinary below-ground trench silos with earth walls and two in above-ground trench silos with walls made from concrete slabs. Wilted-bruised herbage was placed into one silo and wilted-long material into three silos. Insufficient silos were available for making control silages from unwilted herbage. The farm manager was advised to avoid wilting for periods much in excess of 24 hours and to ensure that the silos were filled as

rapidly as possible and that thorough consolidation was given.

Samples of both fresh and wilted materials were collected during the filling periods. Temperature readings were obtained by using two silage thermometers which could be inserted into the herbage at depths of up to 3 feet. Information on weather was collected thrice daily from Boghall meteorological sub-station and details are given in appendix 27 along with figures for saturation deficiency.

Shortly after completion of filling, sampling was carried out from top to bottom of each silo with the aid of a silage corer, one core of silage being considered adequate for a preliminary check on preservation. Four to five months later three similar cores of silage were removed from each silo to provide data on quality and digestibility at the time of feeding.

FILLING THE SILOS.

Silo 1.

Wilted-bruised herbage was ensiled in an above-ground trench with a length of 33 ft., width of 12 ft., height of 4½ ft. and capacity of 45 tons.

The field cut for silage had been sown down in 1950 with a complex seeds mixture of grasses

and clovers. At the time of cutting the crop contained 13.4 per cent. crude protein in the dry matter. The labour team consisted of five men, two in the field, one transporting the crop to the silo and two at the silo. One of the two field men was responsible for driving a tractor-drawn prototype forage harvester, the SHEARMOW, and the other for loading the wilted-bruised material when discharged into the trailer.

Whereas in previous field trials the fresh crop was bruised first and then allowed to wilt, in the present experiment the crop was first mown, then wilted and then collected and bruised by the forage harvester. It was noticed that bruising was less severe when the SHEARMOW was driven over the swathes rather than over the standing crop. Photographs 3 and 4 on page 216 show the forage harvester collecting and bruising the wilted swathes.

At the silo one man was responsible for spreading the grass when each load was brought from the field. The second man was provided with a tractor for the sole purpose of 'continuous' consolidation. No records were kept of the number of hours spent on this work though it was considered that more than the normal amount of consolidation was given. The important point

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is that a tractor was provided specially for consolidation and that this was commenced as soon as the first load was ensiled.

Monday 13th June.

Weather conditions were classed as very good. The day was warm and sunny with three-to four-tenths cumulus and a light breeze. A portion of the field, called area 1, was cut between 7.30 a.m. and 11.30 a.m. The herbage was wet from early morning rain which amounted to 0.7 mm. On completion of cutting at 11.30 a.m. a sample of fresh material was collected. It contained 76.6 per cent. moisture. From the results of previous trials using standing herbage it was assumed that the moisture content of the fresh herbage cut at 7.30 a.m. was approximately 2 per cent. units higher than the figure mentioned above for herbage cut at 11.30 a.m. The moisture content at 3.30 p.m. was 67.9 per cent. so that there was an overall drop of about 11 per cent. units after 8 hours wilting.

Ensilage commenced at 3 p.m. and by the end of the afternoon four loads of herbage had been spread and consolidated. The silo was then covered with tarpaulins to keep out rain, a practice which was carried out at the end of each days work.

Tuesday 14th June.

Weather conditions were classed as very poor. The air was cool and the sky overcast. During the early morning heavy rain had fallen amounting to 4.2 m.m. It was followed by slight drizzle until mid-morning when there was a strong breeze. During the rest of the day the weather remained dry.

It had been decided to cut area 2 from 7 a.m. until 12 noon, but due to the onset of rain the operation was not commenced until 10 a.m. Cutting was continued until midday and again from 1 p.m. until 5 p.m. At 10 a.m. the moisture content of the freshly mown material was 81.0 per cent. The corresponding moisture content of wet swathes which had been lying since 11.30 a.m. the previous day was 76.6 per cent. This confirmed the results of previous field trials which indicated that showers of rain had little effect on partially wilted herbage and suggested that a heavy fall of rain was necessary to raise the moisture content of wilted material to that of wet standing herbage.

At 2.30 p.m. a further sample was taken of the herbage which had been lying since 11.30 a.m. the previous day. The moisture content was now 74.0 per cent. so that there was an overall moisture drop of 7 per cent. units after a

wilting period of 27 hours.

Owing to the difficulty of starting the engine attached to the forage harvester it was not possible to commence ensilage until 1 p.m. By the end of the afternoon, however, the remaining swathes in area 1, now exposed for 29 hours, had been bruised and placed in the silo. There was only sufficient time to ensile one load from area 2. At 2.30 p.m. the moisture content of freshly mown herbage collected from area 2 was 78.4 per cent., 2.6 per cent. units lower than that of the fresh herbage cut at 10 a.m. in the same area. This again confirmed previous results which showed the extent to which drying out takes place in a standing crop during the day.

Wednesday 15th June.

Weather conditions were very good. There was a wind and two-tenths cumulus. No rain had fallen overnight. Ensilage was again delayed due to the difficulty of starting the forage harvester, so to help prevent overheating in the silo two loads of long herbage were collected by greencrop loader and ensiled as soon as possible.

Cutting of area 3 was commenced at 9.15 a.m. but ceased at midday since most of area 2 had yet to be ensiled. The moisture content of the freshly cut swathes was 74.6 per cent. At 9.30 a.m. a

sample of herbage which had wilted for 23 hours was taken from area 2. Its moisture content was 73.4 per cent. so that a moisture drop of some 8 per cent. units had occurred since 10.30 a.m. the previous day. At 2.45 a.m. a further sample was taken from area 2, this time from herbage which had wilted for 26 hours. Moisture content was now much lower, 65.9 per cent. and by 4.30 p.m. it was 64.7 per cent.

The first load of bruised material was not collected until the early afternoon. Ensilage continued until 5 p.m. During the evening silage temperatures were recorded at a depth of 3 feet along the length of the silo. The readings were 89°F. (31.7°C.), 81°F. (27.2°C.) and 108°F. (42.2°C.). At the sides of the silo the corresponding readings were 104°F. (40.0°C.), 119°F. (48.3°C.) and 84°F. (28.9°C.)

Thursday 16th June.

Weather conditions were poor. No rain had fallen overnight. It remained dry throughout the day though it was cool with an overcast sky. Much of area 2 still required harvesting but as a result of further troubles with the forage harvester it was decided to collect the herbage as rapidly as possible with the greencrop loader and ensile it in silo 2. Hence no labour was

available for continuing the work at silo 1 though one man with a tractor was available all day for the work of consolidation.

Friday 17th June.

Weather conditions were very good. No rain had fallen overnight. Temperatures were recorded at four positions in the silo; two readings at the centre were 91°F. (32.8°C.) and 103°F. (39.4°C.), and two at the sides 108°F. (42.2°C.) and 115°F. (46.1°C.). During the early morning the swathes of area 3 which had been lying for 48 hours were wet with dew and contained a moisture content of 56.7 per cent. Three loads of this herbage were placed in the silo which was nearly full. A final layer consisting of four loads of unwilted bruised herbage was then ensiled. Sealing was carried out with fertiliser bags covered with four loads of sand which was immediately consolidated.

On the morning of 18th June further temperature recordings were made. The readings ranged between 110°F. (43.3°C.) and 120°F. (48.9°C.) with the exception of one at 125°F. (51.7°C.) On 20th June two more loads of sand were spread and compacted producing a seal with final depth of 1 foot. Temperatures now ranged between

95°F. (35.0°C.) and 105°F. (40.6°C.). The silo was covered with tarpaulins. Four days later on 24th June the tarpaulins were temporarily removed for the purpose of obtaining a preliminary sample of silage. This was done with the aid of a silage corer. The core sample, removed from the full depth of silage, was found to be only slightly warm to the touch. It was of good colour and possessed an acid taste and a pleasant smell. The dry matter content was 33.4 per cent., crude protein content in the dry matter, 12.0 per cent., and pH value, 4.5. The tarpaulins were later replaced by a roof consisting of sections of curved sheets of corrugated aluminium.

Silo 2.

Long herbage of medium - to low - protein content was ensiled in a below-ground silo with earth sides and a capacity of 75 tons. Silo dimensions were: length, 85 ft., width 13 ft. and depth 3 ft. The herbage was partly harvested from the field used for silo 1 and partly from another field which had been sown down in 1949 with a similar seeds mixture of grasses and clovers. The greatest distance between field and silo was approximately 1 mile. Labour was the same as that used for silage 1. The tractor-drawn mower and green crop loader employed for silages 2,3 and

4 are shown in photographs 5 and 6 on page 224. No tarpaulins were used for covering the silo after each day's filling.

Thursday 16th June.

Weather conditions were poor (see under silo 1). At 8 a.m. ensilage was commenced with area 2 herbage which had already received 45 hours wilting. The moisture content was as low as 56.7 per cent. and that of two further samples taken at 9.30 a.m. and 1.30 p.m., 56.3 per cent. and 55.7 per cent. respectively. At 10.30 a.m. a sample was taken from area 3 which had been cut 24 hours previously. Due to the very good weather on that day the moisture content was now as low as the other samples, 56.4 per cent.

Ensilage and consolidation continued all day and by 5 p.m. the whole of area 2 had been harvested and placed in the silo.

Friday 17th June.

Weather conditions were very good (see under silo 1). During the early morning temperatures of 77°F. (25.0°C.), 88°F. (31.1°C.), 88°F. (31.1°C.) and 90°F. (32.2°C.) were recorded in the bottom layer. At 8 a.m. a sample of herbage wilted for 46 hours was collected from area 3. The moisture content was 56.7 per cent., about the same as that contained in the material collected the pre-

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vious morning after only 24 hours wilting. This seems to confirm the fact that when moisture content reaches a low level further wilting is likely to proceed at a slow rate.

No silage was made because the labour team was being employed to finish silo 1. Further, it was only possible to give a total of three hours consolidation, one hour at midday and two hours at night. At 4.30 p.m. silage temperatures ranging from 85°F. (29.4°C.) to 100°F. (37.8°C.) were recorded.

Saturday 18th June.

Weather conditions were again very good. No rain had fallen overnight. A maximum temperature of 110°F. (43.3°C.) was obtained 6 inches below the surface of the silage. The herbage remaining in area 3 was ensiled during the morning and by 11.30 a.m. after 70 hours wilting the moisture content had reached the very low level of 42.9 per cent. After it had been ensiled the overwilted herbage was covered with two loads of freshly bruised material to aid consolidation. Moisture content of the bruised material was 73.4 per cent. No silage was made during the afternoon.

Monday 20th June.

Weather conditions were very poor, it being

cool and overcast with 1.2 m.m. of intermittent rain or drizzle. There was no wind.

The labour team was not available for silage-making but colsolidation was carried out all day. By midday silage temperatures ranged between 120°F. (48.9°C.) and 130°F. (54.4°C.) at depths of 2 feet.

Area 4 was cut between 8 a.m. and 12 noon and again between 4 p.m. and 5 p.m. A sample of the freshly cut, wet herbage, collected at midday had a moisture content of 80.6 per cent.

Tuesday, 21st June.

Weather conditions were good and no rain had fallen overnight. Silage temperatures had not risen further the readings still ranging between 120°F. (48.9°C.) and 130°F. (54.4°C.). Ensilage and consolidation of herbage collected from area 4 continued all day. At 10 a.m. the moisture content of material wilted for 22 hours was 74.6 per cent., so that since 12 noon the previous day there had been a fall of 6 per cent. units of moisture.

Wednesday 22nd June.

Weather conditions were poor but, no rain had fallen overnight. The sky remained overcast until midday when the weather improved, though there was occasional light drizzle. Silage temperatures ranged between 110°F. (43.3°C.) and

120°F. (48.9°C.). The remaining herbage in the first field was ensiled and at 10 a.m. after 48 hours wilting the moisture content was 57.5 per cent.

Thursday 23rd June.

Weather conditions were poor. Again there had been no overnight rain. Some rain fell during the day. Silage temperatures varied between 110°F. (43.3°C.) and 130°F. (54.4°C.). Neither filling nor consolidation was carried out on this day.

Friday 24th June.

Weather conditions were good. Silage temperatures had now reached 130°F. (54.4°C.) so it was decided to ensile unwilted herbage. A start was made on the second field and silage-making was carried out all day. At 11.30 a.m. the moisture content of a sample of freshly cut material was 82.0 per cent.

Saturday 25th June.

Weather conditions were poor. It was cool and cloudy with some drizzle. Silage was made during the morning using material cut the previous day. By 11 a.m., after 24 hours wilting, the moisture content had reached 66.7 per cent. By late morning the silo was nearly full and one

temperature reading of 90°F. (32.2°C.) was recorded at a depth of 3 feet.

Monday 27th June.

. Weather conditions were again poor, it being cool and overcast with some drizzle. In the afternoon there was a strong breeze. Silage temperatures at 9.30 a.m. varied between 110°F. (43.3°C.) and 120°F. (48.9°C.). During the morning the final layer was ensiled and this was followed immediately with a layer of straw and then soil which when consolidated gave a seal depth of 9 inches. No tarpaulins or roof was used to cover the silo.

On 6th July a core of silage was removed from top to bottom of the silo. The material was warm to the touch, of good colour and acid to the taste. It possessed a slight sweet odour. The dry matter content was 32.1 per cent., crude protein content in the dry matter, 9.4 per cent., and pH value 4.2.

Silo 3.

It is clear from the foregoing remarks that some of the herbage placed into silo 2 was severely wilted. It was decided, therefore, to carry out mild wilting of the material allocated for silo 3. Care was taken to avoid cutting too much of the field at one time.

Long material of medium - to low - protein content was harvested from two fields situated near the silo, the second of these being field 2 which had been utilized for completing silo 2. Silo 3 was a below-ground trench with earth sides and a capacity of 45 tons. Dimensions were: length 50 ft., width 14 ft. and height 3 ft.

Monday 27th June.

Weather conditions were poor (see under silo 2). Area 1 consisting of two acres of the first field was cut between 9 a.m. and 12 noon. The first loads were ensiled at 2 p.m. after only 5 hours wilting. Consolidation was commenced immediately. At 10 a.m. the moisture content of the unwilted crop was 74.6 per cent. That of the wilted material collected at 4 p.m. was 66.8 per cent., so that a moisture drop of approximately 8 per cent. units had taken place during 6 hours wilting. The drop, relatively large considering the poor weather conditions, could be attributed to the strong wind which occurred during the afternoon (see under silo 2).

Ensilage ceased at 5 p.m. and tarpaulins were placed over the silo. Between 6 p.m. and 8 p.m. area 2 consisting of two acres of the first field were cut ready for ensiling the following day.

Tuesday 28th June.

Weather conditions were very poor it being cool and overcast with 2.4 m.m. of rain and drizzle, some of which had fallen overnight. Ensilage was commenced in the early morning. At 10.30 a.m. silage temperatures of 80°F. (26.7°C.) to 90°F. (32.2°C.) were recorded, By now the whole of area 1 and most of area 2 had been ensiled. The few remaining swathes in area 2 which had been lying for 14 hours were wet with rain and contained 77 per cent. moisture when ensiled during mid-morning. Between 10.15 a.m. and 12 noon a portion of field 2 called area 3 was cut and ensiled in an unwilted condition. The material was wet and contained 77.6 per cent. moisture. On account of the onset of continuous bad weather ensilage ceased during the afternoon. The remaining swathes were left in the field and the silo was covered.

Wednesday 29th June.

Weather conditions were poor, it being overcast and cool. A little rain fell during the afternoon. As a result of the previous day's very poor weather the moisture content of the remaining swathes in area 3, collected at 7.30 a.m. after 21 hours exposure, had risen by 4.5 per cent. units from 77.6 per cent. to 82.1 per

cent. moisture. On the other hand a sample of standing herbage collected at the same time contained a moisture content of only 77.5 per cent.

Silage-making commenced at 8 a.m. and continued all day. Before the first load was ensiled temperatures were recorded. The readings ranged between 90°F. (32.2°C.) and 100°F. (37.8°C.) By 11.30 a.m. the swathes remaining in area 3 had been collected and ensiled. Area 4 was partly cut between 9.15 a.m. and 12 noon and partly between 1 p.m. and 3 p.m. After 2 hours wilting the herbage in the first section contained 75.5 per cent. moisture. A portion of area 4 was ensiled.

Thursday 30th June.

Weather conditions varied between poor and good. There was no rain. Cloud amounts ranged between seven- and nine-tenths and there was a slight breeze. Silage temperatures did not exceed 85°F. (29.4°C.). At 7.30 a.m. after 18½ hours wilting and at 11 a.m. after 23 hours wilting the moisture contents of the swathes which had been lying in area 4 had fallen to 64.7 per cent. and 62.6 per cent. respectively. The remaining swathes in area 4 were ensiled during the morning. The labour team was not available

for making silage during the afternoon.

Friday 1st July.

Weather conditions were very poor. Silage temperatures ranging from 90°F. (32.2°C.) to 100°F. (37.8°C.) were recorded as soon as the tarpaulins were removed at 7 a.m. Cutting commenced immediately but it began to rain and the tarpaulins were replaced. At 8 a.m. the moisture content of the freshly cut wet swathes was 78.1 per cent. By 8.30 a.m. the rain had temporarily ceased. Ensilage was carried out until 11.30 a.m. when further rain fell and the tarpaulins were again replaced. Work recommenced at 3.30 p.m. and the final layer of material ensiled.

On Saturday 2nd July the silage was covered with soil which was 1 foot deep after it had been consolidated. Temperature readings averaged 110°F. (43.3°C.). On 6th July one core sample of silage was extracted and found to be slightly warm and of good colour and pleasant smell, with the exception of one portion which possessed an odour of butyric acid. Dry matter content was 25.1 per cent., crude protein in the dry matter, 12.4 per cent., and pH value, 4.0.

Silo 4.

Long herbage of medium - to low - protein

content was filled into an above-ground trench silo. Dimensions were the same as for silo 1. The field used for silage was sown down in 1951 with a complex seeds mixture of grasses and clovers. As with silos 1 and 3 tarpaulins were used to protect the silage at night. Labour and equipment were: 2 field men operating a tractor and greencrop loader, 2 men in charge of 2 tractors and trailers and 1 man at the silo. Unfortunately the tractor used for consolidation was unserviceable. It was therefore, necessary to consolidate the silage with the two tractors used for crop transport. The nearness of the field to the silo allowed some time to be spent at consolidation without causing delay to field work. Nevertheless consolidation was spasmodic and not so 'continuous' as for silos 1, 2 and 3.

Monday 4th July.

Weather conditions were generally good though there were occasional showers of rain. The crop was very wet due to a heavy fall of rain the previous day. Area 1 was cut between 2 p.m. and 5 p.m. and five loads were ensiled and consolidated.

Tuesday 5th July.

Weather conditions were good and there were no showers of rain. No rain had fallen overnight.

Area 2 was cut between 8 a.m. and 10 a.m. and again between 3.30 p.m. and 5 p.m. Silage was made all day with herbage collected from area 1.

Wednesday 6th July.

Weather conditions were very good. No rain had fallen overnight. Area 3 was cut between 9.30 a.m. and 12 noon and ensilage proceeded all day. Two samples were collected at 11 a.m. The first was taken from the remaining swathes of area 2, which had been lying for 18½ hours. Moisture content was 59.7 per cent. That of a second sample collected from the freshly mown material in area 3 was 73.7 per cent. By late afternoon all the swathes remaining in the field had been collected and ensiled. At 4.30 p.m. silage temperatures ranging from 100°F. (37.8°C.) to 110°F. (43.3°C.) were recorded. The silo was now half full.

Thursday 7th July.

Weather conditions were again very good and there had been no overnight rain. Silage temperatures averaged 115°F. (46.1°C.). Area 4 was cut between 7.30 a.m. and 8.30 a.m. and again between 10.30 a.m. and 12 noon. Silage was made all day commencing at 7.30 a.m. with fresh material. At 10.30 a.m. one sample of freshly cut

herbage and one of herbage wilted for 2 hours contained moisture contents of 74.4 per cent. and 72.4 per cent. respectively. An extra 3 hours consolidation was given during the evening.

Friday 8th July.

Weather conditions were very good and no rain had fallen overnight. Silage temperature varied between 105°F. (40.6°C.) and 115°F. (46.1°C.) Area 5 was cut between 7.45 a.m. and 9.45 a.m. and also during the afternoon. Moisture content of the freshly cut herbage was 73.2 per cent. Silage-making commenced at 7.30 a.m. and proceeded all day.

Saturday 9th July.

Weather conditions were good though humid. There had been no rain overnight. Silage temperatures now ranged between 120°F. (48.9°C.) and 130°F. (54.4°C.). No ensilage was carried out on this day though consolidation was performed both during the morning and afternoon.

Monday 11th July.

Weather conditions were good and again no rain had fallen overnight. During the morning the final layer of herbage was ensiled and this was followed immediately by a layer of sand which was consolidated.

On Tuesday 12th July a further quantity of sand was applied giving a final seal depth of 9 inches to 1 foot after further compaction. The maximum temperature recorded at a depth of 2 feet was 136°F. (57.8°C.). At a depth of 3 feet temperatures averaged 110°F. (43.3°C.). On Monday 18th July the temperature at a depth of 3 feet in the centre of the silo was 110°F. (43.3°C.). One core sample was removed. The colour and smell of the silage was satisfactory except that one or two portions of the core possessed a slight odour of butyric acid. Dry matter content was 31.6 per cent., crude protein content in the dry matter, 13.6 per cent., and pH value 4.7.

EMPTYING THE SILOS

Quality and digestibility

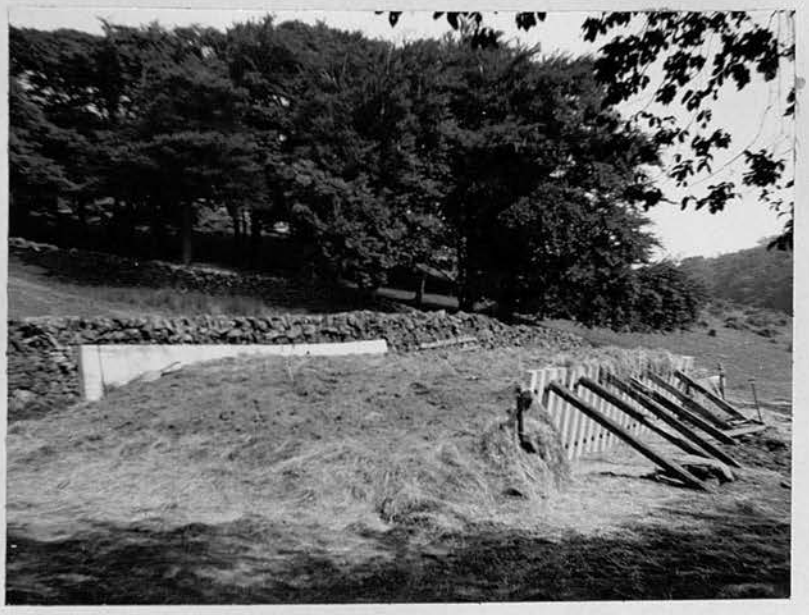
Inspection of silage.

During November 1955 three core samples were removed from top to bottom of each silage at one yard intervals along the length of each silo. The corer was only used for obtaining samples at the middle and not at the sides or ends of the silo. After extraction the cores were examined for colour, taste, smell, waste and mould. Silos 1,2,3 and 4 are shown in photographs 7,8,9 and 10 respectively, (pages 237-238).

7.

8.

9.



10.

Silage 1.

The silage was satisfactory with respect to colour, taste and smell. There was no trace of a sweet odour. Immediately below the seal there was half an inch of waste silage and beneath it ½ an inch of mouldy material.

Silage 2.

Some portions of the silage possessed a slightly sweet smell though the tops of the cores were distinctly butyric in odour. The smell of the middle of the cores ressembled that of good unwilted silage. The cores as a whole were slightly brown in colour. The material did not taste acid. Below the seal there was 2 inches of waste and beneath it 1½ inches of mouldy silage.

Silage 3.

This silage was more moist than silages 1 or 2. Its colour was satisfactory though there was a strong odour of butyric acid. Below the seal there was ½ an inch of waste material but beneath it there was no mould.

Silage 4.

In colour and smell the silage was satisfactory except the lower portion of the cores which smelt of butyric acid. No acid taste was detected when small pieces of silage were placed on the tongue. Waste silage at the top amounted to

2 inches while beneath it there was 2 inches of mouldy material.

Chemical analysis

Immediately after inspection each group of three cores was divided into three parts to correspond with the top, middle and bottom layers of silage. The materials were packed tightly into tins. At the laboratory the bulked samples were thoroughly mixed and passed through a mincing machine. Results of chemical analysis are given in table 57 on page 241 which also shows important data relating to the original herbage at the time of ensilage.

Although the silages were made at different times and from different crops the analytical results are sufficiently comparable for conclusions of practical importance to be made.

The figures for moisture content of silages 1 and 2 show that the 70 per cent. level had been obtained i.e. average moisture contents of 70.4 per cent. and 70.3 per cent. respectively compared with averages of 77.6 per cent. and 78.6 per cent. in the two original unwilted materials. The average moisture content of silage 3 was much higher than that of silages 1 and 2, i.e. 75.2 per cent., compared with 76.9 per cent. in the original unwilted crop. It will be remembered

Table 57 Chemical Analyses of Four Wilted Grass-Clover Silages Made in Trench Silos During Summer 1955.

(each result for the silages is a means of duplicate estimations).

THE CROPS							THE SILAGES								
Silo Number	Weather During Making	Crop Treatment	Wilted Herbage Lowest recorded Moisture content %	Unwilted Herbage Moisture Content %	Days Before Silo Sealed	Temperature in Silo °F and °C	Silage Number	Silage Layer	Moisture Content %	Dry Matter %	Butyric Acid (in fresh material) %	Lactic Acid %	Acetic Acid %	pH Value	Crude Protein in D.M. %	Digestibility of Crude Protein * %
1	Very good	Wilted and Bruised Herbage	56.7 after 48 hrs.wilting	77.6	5	91°F to 120°F 32.8°c to 48.9°C. One reading at 125°F, 51.7°C	1	Top	65.5	34.5	0.11	0.89	0.47	4.4	11.9	71.1
								Middle	72.9	27.1	0.14	0.72	0.61	4.3	12.8	73.1
								bottom	72.8	27.2	0.13	1.18	0.48	4.0	12.0	73.1
								average	70.4	29.6	0.13	0.93	0.52	4.2	12.2	72.5
2	Very poor to Very good	Wilted Long Herbage	42.9 after 70 hrs.wilting	78.6	12	88°F to 130°F 31.1°C to 54.4°C.Frequent readings at 130°F, 54.4°C.	2	Top	71.0	29.0	0.00	1.26	0.21	4.0	11.8	57.9
								Middle	72.1	27.9	0.02	1.48	0.24	4.2	9.4	65.8
								bottom	67.9	32.1	0.00	1.20	0.25	4.4	11.6	62.4
								average	70.3	29.7	0.01	1.31	0.23	4.2	10.9	62.0
3	Poor to Very Poor	Wilted long herbage	62.6 after 23 hrs.wilting	76.9	6	80°F to 110°F 26.7°C to 43.3°C. One reading at 110°F, 43.3°C.	3	Top	75.5	24.5	0.32	1.38	0.31	4.6	15.3	71.1
								Middle	78.1	21.9	0.17	1.70	0.39	4.2	13.7	74.4
								bottom	72.1	27.9	0.15	1.83	0.32	4.0	11.4	74.6
								average	75.2	24.8	0.21	1.64	0.34	4.3	13.5	73.4
4	Good to Very Good	Wilted long herbage	59.7 after 18½ hrs.wilting	73.8	8	100°F to 136°F 37.8°C to 57.8°C. One reading at 136°F, 57.8°C.	4	Top	65.5	34.5	0.04	0.64	0.15	4.9	12.9	63.2
								Middle	65.2	34.8	0.18	0.99	0.15	4.8	12.6	69.9
								bottom	60.3	39.7	0.20	0.91	0.47	4.8	11.9	73.5
								average	63.7	36.3	0.14	0.85	0.26	4.8	12.5	68.9

* Determined in the Laboratory by the pepsin digestion method.

that the material placed into silo 3 received only a few hours wilting and that in any case weather conditions were not conducive to rapid drying. The driest silage, silage 4, contained a moisture content well below the 70 per cent. level, i.e. 63.7 per cent., compared with 73.8 per cent. in the unwilted crop. The table shows that there was no appreciable difference in moisture content of the different layers of each silage, which is surprising considering the extreme variations in moisture content of the ingoing materials. It will be seen that the top layers of the unroofed silages 2, 3 and 4 showed no signs of rain seepage. This would be due to the application of greater than normal thicknesses of seal and to the unusually dry season.

Results for organic acids indicate that the butyric acid content was low in all four silages but greatest in silage 3 with the highest moisture content. Lactic acid contents were moderately high in all silages though the content of acetic acid was greatest in the wilted-bruised material. Values for pH were low in silages 1, 2 and 3 containing a dry matter level of 25 to 30 per cent., though in silage 4 with a dry matter content exceeding 35 per cent. pH value was relatively high, 4.8.

The most interesting results are those per-

taining to digestibility of the crude protein fractions, particularly when considered in relation to the type of weather occurring during ensilage, the lowest moisture content recorded during ensilage, the number of days between commencement and completion of filling, the highest temperatures recorded at the time of making the silage and the average moisture and dry matter contents of the final products.

It will be noticed that without exception the digestibility of the top layers of silage were less than that of the middle or bottom layers. This would be expected since the highest temperatures normally occur in the top, least compacted, layer of silage.

The results for protein digestibility are comparable since all four silages were made from grass crops cut at an advanced stage of growth containing low - to medium - protein contents. Silages 1 and 3 were highest in protein digestibility, 72.5 per cent. and 73.4 per cent. respectively which are normal figures for grass silage. It will be remembered, however, that silage 1 was made during very good weather with some of the material in an overwilted condition, and that the highest recorded temperature in the silo was 125^{o}F. (51.7^{o}C.). The ensiled material had, therefore, been submitted to conditions

favourable to depression of protein digestibility. In fact there was no depression and this would be due to the silage having been made from bruised material, easy to compress in the silo.

The similar high average figure for protein digestibility in silage 3 is explainable by the fact that the silage was made during cool weather conditions and that the herbage was only slightly wilted giving the relatively high moisture content of 75.2 per cent. in the final product. On the other hand silages 2 and 4 became overheated, the average protein digestibilities being 62.0 per cent. and 68.9 per cent. respectively. Considering the high temperatures attained in these two silages the depressions in protein digestibility do not seem excessive which indicates the effectiveness of thorough consolidation, even when stemmy material has been wilted, and also of further consolidation after the silo has been sealed.

Protein digestibility was lowest in silage 2 (62.0 per cent.) because: (a) ensilage was carried out spasmodically (b) the distance between field and silo was considerable and hence rate of filling was slow (c) severely wilted material was placed in the bottom of the silo, before silo 1 had been completed.

Silage 4 with the much lower moisture content

of 63.7 per cent. was less affected by overheating (protein digestibility 68.9 per cent.) which would be partly due to the nearness of the field to the silo and hence a more rapid rate of filling.

An interesting point arising out of the results in table 57 concerns the relationship between dry matter percentage and percentage digestibility of the crude protein. The following hypothetical case has been devised to illustrate this point:

If an animal is fed 100 lb. fresh, unwilted silage containing a dry matter content of 18 per cent., a crude protein content in the dry matter of 12 per cent. and a crude protein digestibility of 72 per cent. then the amount of crude protein available for digestion by the animal is 1.6 lb. Likewise, if similar material is ensiled with a dry matter content of 24 per cent. then 1.9 lb. crude protein is available to the animal. In 100 lb. of slightly brown silage, however, containing a dry matter content of 30 per cent. and a lower protein digestibility of 65 per cent. there is as much as 2.3 lb. crude protein available for digestion.

The greater amount of available crude protein in the wilted silage would, of course, be due to ensiling a greater quantity of total nutrients and a smaller quantity of water compared to that

obtained from unwilted material. Thus economically it is doubtful where any advantage would be gained. But solely from the point of view of the animal more crude protein would be available from a unit weight of wilted silage than from a similar quantity of unwilted material.

Feeding the silage.

Extended inspection.

Silages 1 and 2 were opened for feeding during the first week of November 1955 and silages 3 and 4 during the middle of January 1956.

Silages 2 and 3, made in below-ground silos with earth walls, contained negligible amounts of side waste which indicated the efficiency of tractor consolidation at the time of filling. Silage 2 was slightly brown and contained occasional patches of mould at the sides and in the centre but silage 3 contained no mould.

On the other hand silages 1 and 4 made in above-ground silos with concrete walls contained a considerable amount of side waste, between 6 inches and 1 foot. The large amount of inedible material at the sides would be directly due to insufficient tractor consolidation since there is always a danger of driving a tractor too near the edge of a surface silo with walls only 4 or 5 feet high.

Waste extended to as much as 1 foot in depth at each end of silo 4 containing the driest of the four silages. There was some waste at the ends of silo 1 but the most important point regarding this silage, made from bruised material, was that it tended to become mouldy during the course of feeding. The silage was satisfactory in colour compared to silage 4 which was slightly brown.

Type of cattle, rate of feeding, palatability.

No actual experiments were carried out when the silos were opened; only general observations were made at the time of feeding the silages.

Silage 1.

Twelve 7 month old blue-grey calves were allowed unrestricted access to the silo during the day. Both ends of the silo were opened for self-feeding though it should be mentioned that one end still contained a small quantity of good quality unwilted bruised silage left over from the previous winter. It was frequently observed that the calves much preferred the wilted-bruised than the fresh-bruised material. It was also noticed that the bruised-wilted silage became mouldy more rapidly than could be accounted for by the slow rate of feeding.

In addition to silage the calves each received

3 lb. hay and 3 lb. of a concentrate mixture consisting of oats and earth nut cake placed in a shed near the silo. The hay was fed at night, along with half the concentrate mixture, the remaining concentrates being offered to the calves in the early morning before they were allowed access to silage.

Silage 2.

The silage was cut and forked out in the conventional way. It was fed indoors to thirteen 20 month old heifers bred from blue-grey cows crossed with an Aberdeen Angus bull, and to seventeen 9 month old calves also out of blue-grey cows. The silage was palatable and eaten greedily by both groups of cattle which also received hay and oats. Whereas in the past the cattle tended to waste ordinary silage they were always ready to eat more wilted material than the quantity offered. The silo was emptied rapidly and the stocksman was of the opinion that the animals consumed more than their required amount of silage.

Silo 3.

The silo was opened during the middle of January and its contents was fed indoors to the same two groups of cattle given silage 2. Silage 3 was less palatable than silages 1 or 2, particularly at the ends of the silo, and in consequence

was eaten less greedily.

Silage 4.

Fourteen in-calf Galloway breeding cows, out wintering on the hill, were allowed access to both ends of the silo for three hours each day from 8 a.m. until 11 a.m. They also received straw which was distributed on the ground.

DISCUSSION

A few points of interest arise out of the farm investigation. Wilting seemed to proceed very slowly in herbage which unintentionally had been left for too long a period in the field. Mihin (1940) maintained that a reduced rate of moisture fall during the later stages of wilting was due to an increase in the concentration of cell sap.

Information obtained for rate of wilting during very good weather confirms the conclusions drawn by Murdoch (1953) from his experiments i.e. that during such weather conditions, to safeguard against overwilting and overheating it may be necessary to restrict the period of exposure to less than 12 to 24 hours. The results obtained on the quality of silage in the bottom layers of four trench silos do not support the views held by Shepherd (1952) who says that production of butyric acid in the bottom of a trench silo can be avoided by delaying filling until the temperature of the first 2 - 3 ft. layer of partially wilted herbage has risen to 100°F. (37.8°C.). Shepherd was probably referring to chopped material, which is easy to compress, but so far as long herbage is concerned it was obvious from the Edinburgh experiments that the practice of consolidating right from the commencement of ensilage was a safe

and correct one to adopt. Not only was the greatest possible control of temperature attained but the quality of the silage at the bottom was no poorer than that of the middle or top layers (see page 241).

Unfortunately it is impossible to carry out the recommendations of Dijkstra and Brandsma (1955) to wilt to as low as 50 per cent. moisture content and thus reduce appreciably the loss of digestible crude protein. The practice of severe wilting may be possible in the Netherlands where the small upright silo is gradually replacing the clamp. But in Britain where large horizontal silos are employed it is almost certain that any saving of digestible crude protein, resulting from severe wilting, would be offset by the deleterious effect of excessive overheating.

Results obtained for crude protein digestibility of the trench silages compare favourably with those obtained by Bailey et al (1955) who used large upright experimental silos. These investigators found that the crude protein digestibility of wilted silage, containing 60 - 65 per cent. moisture, was 58.0 per cent., about 10 per cent. units less than the crude protein digestibility of the fresh silage, 67.4 per cent. The maximum temperature reached in the wilted silage was 127 ^{o}F. The average crude protein

digestibility of the two Edinburgh silages, overheated to the same degree and containing 65-70 per cent. moisture, was 65.5 per cent., about 7 per cent. units less than the crude protein digestibility of the two silages which had received adequate consolidation, 73.0 per cent. (see page 241).

A final point concerns that of the feeding of wilted silage. Woodward and Shepherd (1942) state that wilted silage should be consumed faster than unwilted silage. This point is agreed upon with respect to the bruised silage which was observed to develop mould during the course of slow self-feeding of calves.

SUMMARY AND CONCLUSIONS

1. During summer 1955 four farm silages were made from wilted grass and clover, silage 1 from bruised material and silages 2, 3 and 4 from long material, all of medium - to low - crude protein content.

2. The season was exceptionally warm and dry. The crops were stemmy and when cut contained the low average moisture content of 76.6 per cent. Based on a classification of weather, devised from earlier investigations, meteorological information showed that weather conditions during ensilage of silo 1 was very good; silo 2, very poor - very good; silo 3, poor - very poor and silo 4, good - very good. A proportion of silage was, therefore, made under conditions highly favourable towards overheating in the silo.

3. It was proposed always to cut one day in advance of filling and to wilt each area for about 24 hours. Due to inexperience with harvesting wilted material more herbage was sometimes cut than could be collected and ensiled in one day so that some of the material was severely wilted. The primary cause of overwilting, however, was faulty machinery which delayed work in the field.

4. Results of moisture determinations tended to confirm previous field trials which showed that (a) marked moisture drops occurred in all but very poor weather (b) no advantage was gained by postponing cutting until surface moisture had evaporated and (c) wilted material still lying in the field was not much affected by rain showers.

5. Wilted silage made from long herbage, containing a minimum of overheated and mouldy material, can be produced by making sure that (a) filling is continuous, except during bad weather (b) as much herbage as possible is wilted for periods of up to 24 hours only (c) consolidation is performed continuously, starting with the first layer (d) filling is carried out rapidly and commenced at the beginning and not at the end of the week (e) no waiting periods are allowed for temperature to rise, and a layer of unwilted material ensiled if temperature reaches 120°F. (48.9°C.), (f) unwilted herbage is used during the final day's filling and (g) sealing is performed immediately to give a soil depth of at least 9 inches after compression by the tractor.

6. Results showed that overheating and moulding is much less likely to occur in wilted material which has been bruised than in wilted long herbage: It is concluded that for best results some form of mechanical treatment is advisable.

7. Chemical analyses of the edible products showed silages 1, 2, 3 and 4 to contain average

percentage moisture contents of 70.4, 70.3, 75.2 and 63.7, average percentage crude protein digestibilities of 72.5, 62.0, 73.4 and 68.9, average percentage butyric acid contents in the fresh material of 0.13, 0.01, 0.21 and 0.14, average percentage lactic acid contents of 0.93, 1.31, 1.64 and 0.85, average percentage acetic acid contents of 0.52, 0.23, 0.34 and 0.26 and average pH values of 4.2, 4.2, 4.3 and 4.8.

8. Excluding waste and mouldy material preservation was satisfactory in all four silages but temperatures of up to 130°F. (54.4°C.) in silage 2 and 136°F. (57.8°C.) in silage 4 caused depressions of crude protein digestibility amounting to 5 per cent. and 15 per cent. respectively. The depressions were small considering the stemminess of the crop and frequency of overwilting but much greater depressions of protein digestibility would probably have occurred had less consolidation been given.

9. Visual inspection showed silages 2 and 4 to be slightly brown and to possess a slightly sweet odour; characteristics which were not present in silages 1 and 3. The amount of top waste and mouldy material was by far the greater in silage 4 containing the lowest moisture content of 63.7 per cent. The degree of side waste was controlled by type of silo, not by dryness of herbage.

10. The silages were fed to Galloway cows, and also to 20 month old heifers and 7 to 9 month old calves out of blue-grey cows. Silage 3 of highest moisture content, 75.2 per cent., was the least palatable, it being consumed less greedily than the other three silages.

11. Finally, while wilted stemmy grass and clover herbage of medium - to low - crude protein content can give a satisfactory silage with a moisture content of 70 per cent., and with relatively small amounts of waste and mouldy material, it is clear that a depression of about 10 per cent of crude protein digestibility is inevitable unless the crop has been bruised to aid consolidation. Provided all the conditions under point 5 above are adhered to then satisfactory silage can be made from partially wilted herbage in all weather conditions except that classed as 'very poor'. Faced with such an exacting list of rules it is doubtful whether many farmers would seriously consider partial wilting of crops for silage a worth while method.

No results are available for farm silages made from wilted leafy herbage but it is thought that the danger of producing overheated and mouldy silage would be less with leafy grass and clover than with stemmy material such as that used during the present investigation.

SECTION 5

BASIC DATA - APPENDICES

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APPENDIX I

Details of Grass and Clover Crop used for the 1953 Wilting Trials.

L O N G P E R I O D W I L T I N G

Trial Number	Date	Time of Day	Wilting Period	Crop Height	Stage of Growth	Physical Condition
1	14th May	3.30 p.m. crop cut	18 hr.	8-11"	All leaf	Sward wet from rain.
	15th May	6.30 a.m.	=	=	=	tops of swathes wet.
		9.30 a.m. lifted after	18 hr.	=	=	tops of swathes wet.
		12.30 p.m. lifted after	21 hr.	=	=	tops dry, bottoms wet.
		3.30 p.m. lifted after	24 hr.	=	=	whole swathes almost dry.
2	21st May	3.30 p.m. crop cut	=	12-15"	Leafy - heads just visible	Moist at base of sward.
	22nd May	6.30 a.m.	=	=	=	tops of swathes wet with dew.
		9.30 a.m. lifted after	18 hr.	=	=	uncut grass still moist.
		12.30 p.m. lifted after	21 hr.	=	=	uncut grass still moist.
		3.30 p.m. lifted after	24 hr.	=	=	uncut grass dry.
3	28th May	3.30 p.m. crop cut		18-20"	Leafy - heads emerging	Sward dry.
	29th May	6.30 a.m.	=	=	=	swathes v. wet from rain.
		9.30 a.m. lifted after	18 hr.	=	=	tops of swathes wet.
		12.30 p.m. lifted after	21 hr.	=	=	tops of swathes dry.
		3.30 p.m. lifted after	24 hr.	=	=	tops of swathes dry.
4	8th June	3.30 p.m. crop cut		30-33"	Leaf, stem and heads.	Sward dry.
	9th June	6.30 a.m.	=	=	=	tops of swathes moist.
		9.30 a.m. lifted after	18 hr.	=	=	centres of swathes dry.
		12.30 p.m. lifted after	21 hr.	=	=	whole swathes dry.
		3.30 p.m. lifted after	24 hr.	=	=	whole swathes dry.
5	11th June	3.30 p.m. crop cut		33-40"	Mostly stem and heads	Sward wet at base
	12th June	6.30 a.m.	=	=	=	
		9.30 a.m. lifted after	18 hr.	=	=	swathes dry.
		12.30 p.m. lifted after	21 hr.	=	=	swathes dry.
		3.30 p.m. lifted after	24 hr.	=	=	swathes dry.

Cont./

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Details of Grass and Clover Crop used for the 1953 Wilting Trials.

SHORT PERIOD WILTING

Trial Number	Date	Time of Day	Wilting Period	Crop Height	Stage of Growth	Physical Condition
1	14th May			8-11"	All leaf	Sward wet from rain.
	15th May	6.30 a.m. crop cut		-	-	tops of swathes almost dry.
		9.30 a.m. lifted after	3 hr.	-	-	tops dry, bottoms nearly dry.
		12.30 p.m. lifted after	6 hr.	-	-	whole swathes almost dry.
		3.30 p.m. lifted after	9 hr.	-	-	
2	21st May			12-15"	leafy - heads just visible	Sward wet with dew.
	22nd May	6.30 a.m. crop cut		-	-	uncut herbage still moist.
		9.30 a.m. lifted after	3 hr.	-	-	uncut herbage still moist.
		12.30 p.m. lifted after	6 hr.	-	-	uncut herbage dry.
		3.30 p.m. lifted after	9 hr.	-	-	
3	28th May			18-20"	leafy - heads emerging	Sward very wet from rain.
	29th May	6.30 a.m. crop cut		-	-	tops of swathes dry.
		9.30 a.m. lifted after	3 hr.	-	-	tops of swathes dry.
		12.30 p.m. lifted after	6 hr.	-	-	tops of swathes dry.
		3.30 p.m. lifted after	9 hr.	-	-	
4	8th June			30-33"	leaf, stem and heads	Sward moist.
	9th June	10.30 a.m. crop cut		-	-	swathes dry.
		1.30 p.m. lifted after	3 hr.	-	-	swathes dry.
		4.30 p.m. lifted after	6 hr.	-	-	swathes dry.
		7.30 p.m. lifted after	9 hr.	-	-	
5	11th June			33-40"	mostly stem and heads	
	12th June	10.30 a.m. crop cut		-	-	swathes dry.
		1.30 p.m. lifted after	3 hr.	-	-	swathes dry.
		4.30 p.m. lifted after	6 hr.	-	-	swathes dry.
		7.30 p.m. lifted after	9 hr.	-	-	

contd.

APPENDIX I cont.

Details of Grass and Clover Crop used for the 1954 Wilting Trials.

LONG PERIOD WILTING

Trial Number	Date	Time of Day	Wilting Period	Crop Height	Stage of Growth	Physical Condition
6	19th May	3.30 p.m. crop cut		12-15"	leafy	Sward moist at base.
		6.30 a.m.		-	-	sward wet from rain.
	20th May	9.30 a.m. lifted after	18 hr.	-	-	tops of swathes dry, bottoms moist.
		12.30 p.m. lifted after	21 hr.	-	-	tops of swathes dry, bottoms moist.
		3.30 p.m. lifted after	24 hr.	-	-	tops of swathes dry, bottoms moist.
7	27th May	3.30 p.m. crop cut		21-24"	leafy - heads partly emerged	Sward moist at base.
		6.30 a.m. lifted after	18 hr.	-	-	tops of swathes wet from rain.
	28th May	9.30 a.m. lifted after	18 hr.	-	-	tops of swathes wet from rain.
		12.30 p.m. lifted after	21 hr.	-	-	
		3.30 p.m. lifted after	24 hr.	-	-	swathes still rather wet.
8	10th June	3.30 p.m. crop cut		30-33"	leaf, stem and heads	Sward wet at base.
		6.30 a.m.		-	-	
	11th June	9.30 a.m. lifted after	18 hr.	-	-	tops of swathes wet from rain.
		12.30 p.m. lifted after	21 hr.	-	-	tops and bottoms wet.
		3.30 p.m. lifted after	24 hr.	-	-	bottom of swathes rather wet.

Details of Grass and Clover Crop used for the 1954 Wilting Trials.

SHORT PERIOD WILTING

Trial Number	Date	Time of Day	Wilting Period	Crop Height	Stage of Growth	Physical Condition
6	19th May					
		(6.30 a.m. crop cut		12-15"	leafy	Sward moist at base.
	20th May	(9.30 a.m. lifted after	3 hr.	-	-	tops of swathes dry, bottoms moist.
		(12.30 p.m. lifted after	6 hr.	-	-	tops of swathes dry, bottoms moist.
		(3.30 p.m. lifted after	9 hr.	-	-	tops of swathes dry, bottoms moist.
7	27th May					
		(10.30 a.m. crop cut		21-24"	leafy - heads partly emerged	Sward rather wet.
	28th May	(1.30 p.m. lifted after	3 hr.	-	-	
		(4.30 p.m. lifted after	6 hr.	-	-	
		(7.30 p.m. lifted after	9 hr.	-	-	swathes dry.
8	10th June					
		(10.30 a.m. crop cut		30-33"	leaf, stem and heads	Sward wet at base.
	11th June	(1.30 p.m. lifted after	3 hr.	-	-	
		(4.30 p.m. lifted after	6 hr.	-	-	swathe bottoms rather wet.
		(7.30 p.m. lifted after	9 hr.	-	-	swathe bottoms rather wet.

APPENDIX 2

Meteorological Data extracted from 'The Book of Normals of Meteorological Elements for the British Isles'. Also from 'The Climate of the British Isles' by E. G. Bilham.

MEAN DAILY SUNSHINE - hours			
Region	May	June	July
Edinburgh	5.3	6.4	5.3
Morpeth	5.5	6.0	5.3
Norwich	6.9	6.8	6.6
Bognor Regis	7.4	7.8	7.3
Averages for 30 years			

NUMBER OF RAIN DAYS			
Region	May	June	July
Edinburgh	14	15	14
Tynemouth	14	13	14
Norwich	13	14	14
Bognor Regis	12	11	11
Averages for 35 years			

AVERAGE RAINFALL - inches			
Region	May	June	July
Edinburgh	1.98	1.88	2.69
Tynemouth	1.99	1.98	2.40
Norwich	1.93	1.93	2.59
Bognor Regis	1.56	1.63	1.86
Averages for 35 years			

WIND SPEED - m.p.h. (July)					
Region	STRONG		MEDIUM		LIGHT
	>38	25-38	13-24	4-12	<4
Edinburgh	0%	0.7%	29%	50%	20%
South Shields	0%	0.7%	23%	50%	27%
Gorleston	0%	2.0%	30%	53%	14%
Kew	0%	0 %	10%	62%	28%
Averages for 9-12 years					

DAILY MAXIMUM AIR TEMPERATURE - °F			
Region	May	June	July
Edinburgh	55	62	65
Morpeth	56	63	66
Norwich	62	68	72
Kew	63	68	72
Averages for 30 years			

RELATIVE HUMIDITY - per cent									
Region	May			June			July		
	7 a.m.	1 p.m.	6 p.m.	7 a.m.	1 p.m.	6 p.m.	7 a.m.	1 p.m.	6 p.m.
Leuchars	83	70	76	81	68	73	86	71	75
Tynemouth	85	75	77	83	75	77	86	74	76
Lincoln	88	68	74	87	68	72	87	65	69
Croydon	84	61	66	81	60	64	83	60	64
Averages for 15 years									

Meteorological Data - 1953 Wilting Trials.

LONG PERIOD WILTING

Trial Number	Date	Time of Day	Wet Bulb °F	Dry Bulb °F	Relative Humidity %	Saturation Deficit mm/Hg.	Precipitation m.m.	Sunshine	hr.
1	14th May							3.30 p.m. - sunset	0.0
		(10 a.m.	48	52	75	3.0	1.7 m.m. rain recorded at		
	15th May	(					7 a.m. for previous 22 hrs.	sunrise - 3.30 p.m.	2.0
		(					Drizzle fell at 3.30 p.m.		
								Total	2.0
2	21st May						Nil	3.30 p.m. - sunset	4.3
		(10 a.m.	51	55	76	2.7	Rain fell from 7 - 8 a.m.		
	22nd May	(					very slight drizzle at	sunrise - 3.30 p.m.	4.1
		(					12.30 p.m.		
								Total	8.4
3	28th May	3.30 p.m.	-	60	59	5.1	very slight drizzle	3.30 p.m. - sunset	0.1
		(9.30 a.m.	50	55	70	3.2	rain fell from 6 - 7 a.m.		
	29th May	(12.30 p.m.	51	57	66	3.9	thereafter no rain	sunrise - 3.30 p.m.	8.4
		(3.30 p.m.	50	57	61	4.4			
								Total	8.5
4	8th June	2.30 p.m.	59	64	74	4.0	Nil	3.30 p.m. - sunset	3.0
		(9.30 a.m.	49	49	100	0.0	Nil		
	9th June	(12.30 p.m.	59	64	74	4.0	Nil	sunrise - 3.30 p.m.	5.0
		(3.30 p.m.	58	69	51	8.3	Nil		
								Total	8.0
5	11th June	3.0 p.m.	61	67	71	4.9	Nil	3.30 p.m. - sunset	4.7
		(9.30 a.m.	55	58	83	2.0	Nil	sunrise - 3.30 p.m.	2.7
	12th June	(12.15 p.m.	59	65	70	4.8	Nil		
		(3.15 p.m.	62	68	71	5.0	Nil		
								Total	7.4

contd.

Meteorological Data - 1953 Wilting Trials.

SHORT PERIOD WILTING

Trial Number	Date	Time of Day	Wet Bulb °F	Dry Bulb °F	Relative Humidity %	Saturation Deficit mm/Hg.	Precipitation m.m.	Sunshine hr.
1	14th May 15th May	10 a.m.	see long period trials				see long period trials	Total of 2 hours sun between 6.30 a.m. and 3.30 p.m.
2	21st May 22nd May	10 a.m.	see long period trials				rain fell between 7 and 8 a.m. v. slight drizzle at 12.30 p.m.	Total of 4.1 hours sun between 6.30 a.m. and 3.30 p.m.
3	28th May 29th May	6.30 a.m.	-	38	85	0.8	rain fell between 6 and 7 a.m. Thereafter no rain	Total of 8.4 hours sun between 6.30 a.m. and 3.30 p.m.
		8.30 a.m.	51	55	76	2.7		
		9.30 a.m. 12.30 p.m. 3.30 p.m.	see long period trials					
4	8th June 9th June	2.0 p.m.	61	68	67	5.6	Nil	Total of 6.9 hours sun between 10.30 a.m. and 7.30 p.m.
		4.30 p.m.	61	70	59	6.8	Nil	
		7.30 p.m.	58	63	74	3.8	Nil	
5	11th June 12th June	11.15 a.m.	58	62	79	3.0	Nil	Total of 2.7 hours sun between 10.30 a.m. and 7.30 p.m.
		1.45 p.m.	61	67	71	4.9	Nil	
		4.50 p.m.	61	65	80	3.1	Nil	
		7.30 p.m.	55	56	94	0.7	Nil	

Contd.

Meteorological Data - 1954 Wilting Trials.

LONG PERIOD WILTING

Trial Number	Date	Time of Day	Wet Bulb °F	Dry Bulb °F	Relative Humidity %	Saturation Deficit mm/Hg.	Precipitation m.m.	Sunshine	hr.
6	19th May	3.0 p.m.	53	60	63	4.8	Nil	3.30 p.m. - sunset	2.7
		4.30 p.m.	54	62	59	5.7			
		9.0 a.m.	45	50	67	2.9	slight rain at 7 a.m.		
	20th May	12.0 noon.	48	56	55	4.9		sunrise - 3.30 p.m.	4.6
		3.0 p.m.	49	59	47	6.2		Total	7.3
7	27th May	3.0 p.m.	58	66	61	6.0			
		4.30 p.m.	58	64	70	4.6	Nil	3.30 p.m. - sunset	0.0
		9.0 a.m.	57	59	89	1.4	6.8 m.m. rain fell overnight		
	28th May	12.0 noon	58	62	79	3.0		sunrise - 3.30 p.m.	0.7
		3.0 p.m.	57	62	74	3.8		Total	0.7
8	10th June	3.0 p.m.	53	60	63	4.8			
		4.30 p.m.	53	56	82	2.0	Rain commenced at 4.30 p.m.	3.30 p.m. - sunset	0.5
		9.15 a.m.	46	50	74	2.4	4.7 m.m. rain fell between		
	11th June	12.15 p.m.	47	51	75	2.4	4.30 p.m. on 10th June and	sunrise - 3.30 p.m.	0.7
		3.15 p.m.	47	53	63	3.7	9 a.m. on 11th June. Thereafter no more rain.	Total	1.2

contd.

Meteorological Data - 1954 Wilting Trials.

SHORT PERIOD WILTING

Trial Number	Date	Time of Day	Wet Bulb °F	Dry Bulb °F	Relative Humidity %	Saturation Deficit mm/Hg.	Precipitation m.m.	Sunshine
6	19th May	(6 a.m.	44	46	86	1.1	slight rain fell at 7 a.m.	Total of 4.6 hours sun between 6.30 a.m. and 3.30 p.m.
		(9 a.m.						
	20th May	(12 noon	see long period trials					
		(3 p.m.						
7	27th May	(9 a.m.					6.8 m.m. rain fell over-night. v. slight drizzle at 4.45 p.m.	Total of 0.7 hours sun between 10.30 a.m. and 7.30 p.m.
	28th May	(12 noon	see long period trials					
		(3 p.m.						
		(7.30 p.m.	57	59	89	1.4		
8	10th June	(9.15 a.m.					4.7 m.m. rain fell between 4.30 p.m. on 10th June and 9 a.m. on 11th June. Thereafter no rain.	Total of 2.4 hours sun between 10.30 a.m. and 7.30 p.m.
	11th June	(12.15 p.m.	see long period trials					
		(3.15 p.m.						
		(7.30 p.m.	48	52	75	2.5		

APPENDIX 3.

Examples of Diurnal Variation of Saturation Deficiency

Time of Day	30th - 31st July, 1954			18th - 19th September, 1954		
	Air Temperature °F	Relative Humidity %	Saturation Deficit mm/hg	Air Temperature °F	Relative Humidity %	Saturation Deficit mm/hg
7 a.m.	51	85	1.5	37	83	0.9
8 a.m.	51	86	1.4	37	84	0.8
9 a.m.	52	86	1.5	41	85	1.0
10 a.m.	55	86	1.6	45	85	1.3
11 a.m.	56	86	1.6	50.	82	1.7
12 noon	56	75	2.9	52	77	2.3
1 p.m.	56	73	3.0	56	70	3.5
2 p.m.	58	71	3.5	56	65	3.9
3 p.m.	61	67	4.5	56	65	3.9
4 p.m.	61	65	4.8	56	64	4.0
5 p.m.	59	70	4.0	55	63	4.0
6 p.m.	59	67	3.8	55	62	4.1
7 p.m.	58	73	3.3	52	64	3.6
8 p.m.	57	74	3.0	45	76	2.0
9 p.m.	54	76	2.6	45	77	1.9
10 p.m.	53	77	2.4	44	78	1.7
11 p.m.	52	78	2.2	42	80	1.4
12 midnight	51	79	2.0	40	81	1.2
1 a.m.	51	80	1.9	40	82	1.0
2 a.m.	51	81	1.8	40	83	1.1
3 a.m.	51	82	1.7	42	84	1.1
4 a.m.	51	82	1.7	42	84	1.0
5 a.m.	51	83	1.6	42	85	0.9
6 a.m.	51	84	1.5	41	86	0.9
7 a.m.	51	88	1.2	42	87	0.9

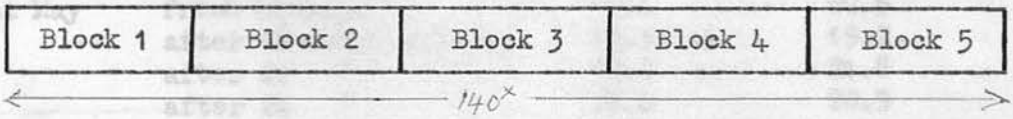
APPENDIX 4

Randomised Plots - 1953 Wilting Trials.

(L = long period wilting, S = short period wilting.)

Block 1	L7	L3	L2	L5	S3	L1	L4	S2	S5	S7	S4	S1	S6	L6
Block 2	S4	L3	S1	L1	S2	L7	L5	S3	S5	L6	S7	L4	L2	S6
Block 3	S7	S2	S3	L5	L4	S4	L7	L1	S5	L2	L6	S1	S6	L3
Block 4	L1	L3	L2	S3	L7	L6	S6	S7	L4	S2	L5	S5	S4	S1
Block 5	L3	S5	S7	L1	L6	S3	S4	L5	S1	S2	L7	S6	L4	L2

Blocks laid out as follows:-

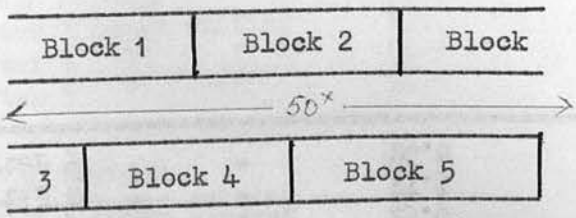


Randomised Plots - 1954 Wilting Trials.

(L = long period wilting, S = short period wilting)

Block 1	L5	S2	S4	L3	L4	L2	S1	S3	L1	S5
Block 2	S2	L1	L3	S1	S3	S4	L2	L5	S5	L4
Block 3	S5	S2	L1	L5	L2	S4	L4	S1	S3	L3
Block 4	S1	S5	L5	S2	L1	L2	S4	L4	S3	L3
Block 5	L3	S4	S2	L5	S1	S5	S3	L1	L4	L2

Blocks laid out as follows:-



APPENDIX 5

Chemical Composition of Fresh and Wilted Grass-Clover Herbage-1953 Wilting Trials.

(Each result is a mean of five replicates)

Trial Number	Date	Crop Treatment	Dry Matter Content %	Crude Protein in dry matter %	Crude Fibre %
		LONG PERIOD WILTING			
1	14th May	fresh herbage	15.7	22.2	19.2
		after 18 hours wilting	13.8	22.1	19.8
		after 21 " "	19.5	22.1	19.9
		after 24 " "	22.3	22.4	18.2
2	21st May	fresh herbage	15.4	20.5	23.9
		after 18 hours wilting	17.3	19.2	24.9
		after 21 " "	20.2	21.8	24.5
		after 24 " "	26.0	20.9	23.6
3	28th May	fresh herbage	16.1	16.0	27.4
		after 18 hours wilting	23.4	15.0	28.0
		after 21 " "	27.3	15.6	27.3
		after 24 " "	29.9	15.1	28.0
4	8th June	fresh herbage	18.2	12.3	30.1
		after 18 hours wilting	21.6	12.8	30.6
		after 21 " "	24.7	13.2	30.6
		after 24 " "	31.0	12.0	31.6
5	11th June	fresh herbage	18.7	9.7	30.9
		after 18 hours wilting	23.3	10.7	31.5
		after 21 " "	26.9	11.4	31.6
		after 24 " "	33.2	10.8	31.7
		SHORT PERIOD WILTING			
1	15th May	fresh herbage	12.7	22.1	20.5
		after 3 hours wilting	16.2	21.6	18.9
		after 6 " "	19.8	24.3	19.0
		after 9 " "	21.9	21.6	19.9
2	22nd May	fresh herbage	13.9	18.6	25.1
		after 3 hours wilting	12.7	18.2	25.8
		after 6 " "	16.2	19.4	23.8
		after 9 " "	24.1	19.5	25.2
3	29th May	fresh herbage	14.7	14.6	30.9
		after 3 hours wilting	18.2	15.3	28.3
		after 6 " "	24.1	14.9	28.6
		after 9 " "	30.2	14.3	29.4
4	9th June	fresh herbage	17.2	13.0	31.0
		after 3 hours wilting	23.8	13.6	29.6
		after 6 " "	29.1	13.1	29.9
		after 9 " "	29.8	14.9	30.1
5	12th June	fresh herbage	17.8	11.4	31.9
		after 3 hours wilting	23.0	12.2	30.8
		after 6 " "	27.3	10.7	31.8
		after 9 " "	26.8	11.2	32.1

APPENDIX 5 contd.

Chemical Composition of Fresh and Wilted Grass-Clover Herbage - 1954 Wilting Trials.

Trial Number	Date	Crop Treatment	Dry Matter Content %	Crude Protein in Dry Matter %
LONG PERIOD WILTING				
6	19th May	fresh crop	15.7	20.6
		after 18 hours wilting	20.5	-
		after 21 " "	23.2	-
		after 24 " "	27.7	-
7	27th May	fresh crop	15.1	17.6
		after 18 hours wilting	13.0	-
		after 21 " "	14.4	-
		after 24 " "	15.8	-
8	10th June	fresh crop	13.3	12.7
		after 18 hours wilting	13.5	-
		after 21 " "	15.1	-
		after 24 " "	17.9	--
SHORT PERIOD WILTING				
6	20th May	fresh crop	14.9	20.6
		after 3 hours wilting	16.1	-
		after 6 " "	18.7	-
		after 9 " "	22.4	-
7	28th May	fresh crop	12.6	17.6
		after 3 hours wilting	15.1	-
		after 6 " "	15.8	-
		after 9 " "	17.0	b-
8	11th June	fresh crop	14.4	12.7
		after 3 hours wilting	16.8	-
		after 6 " "	19.5	-
		after 9 " "	22.2	-

(Each result is a mean of five replicates)

APPENDIX 6

Percentage Moisture Contents of Fresh and Wilted Grass and Clover Herbages - 1953 Wilting Trials.

LONG PERIOD WILTING						
Trial Number	Replicate Number	Date	Fresh Herbage	18 hours wilting	21 hours wilting	24 hours wilting
1	1	14th-15th May	82.1)	87.1)	85.2)	80.4)
	2		84.4)	86.0)	79.4)	78.5)
	3		85.6)84.3	87.0)86.2	82.2)80.5	79.3)77.7
	4		84.3)	85.1)	76.2)	74.1)
	5		84.9)	85.6)	79.7)	76.3)
2	1	21st-22nd May	85.2)	83.4)	81.7)	75.6)
	2		85.6)	85.1)	80.1)	74.1)
	3		84.3)84.6	84.6)82.7	79.5)79.8	71.0)74.0
	4		85.8)	84.4)	81.3)	75.3)
	5		82.1)	75.9)	76.6)	74.0)
3	1	28th-29th May	84.2)	75.0)	73.4)	71.3)
	2		85.3)	79.3)	74.9)	69.8)
	3		84.4)83.9	78.6)76.6	73.2)72.7	72.6)70.1
	4		83.6)	76.4)	71.3)	68.3)
	5		81.9)	73.9)	70.7)	68.5)
4	1	8th-9th June	82.5)	78.5)	75.7)	68.8)
	2		81.4)	77.5)	73.9)	68.8)
	3		83.2)81.8	79.6)78.4	73.9)75.3	70.2)69.0
	4		80.3)	77.4)	76.3)	67.3)
	5		81.7)	78.9)	76.7)	69.7)
5	1	11th-12th June	81.3)	76.7)	71.2)	65.1)
	2		80.8)	78.2)	72.7)	67.1)
	3		79.7)81.3	73.4)76.7	71.3)73.1	66.0)66.8
	4		83.3)	78.3)	76.2)	69.3)
	5		81.3)	76.8)	74.0)	66.3)
Combined Averages			83.2	80.1	76.3	71.5

(contd.)

APPENDIX 6 contd.

Percentage Moisture Contents of Fresh and Wilted Grass and Clover Herbages - 1953 Wilting Trials.

SHORT PERIOD WILTING						
Trial Number	Replicate Number	Date	Fresh Herbage	3 hours wilting	6 hours wilting	9 hours wilting
1	1	15th May	86.9)	84.8)	80.3)	80.3)
	2		88.0)	84.0)	81.6)	77.1)
	3		88.7)87.3	84.8)83.8	80.2)80.2	78.6)78.1
	4		87.6)	85.0)	79.2)	77.6)
	5		85.2)	80.6)	79.6)	76.9)
2	1	22nd May	87.3)	85.1)	83.8)	78.0)
	2		86.2)	88.3)	84.1)	76.2)
	3		86.5)86.1	89.0)87.3	84.2)83.8	73.4)75.9
	4		86.1)	88.8)	85.8)	78.0)
	5		84.3)	85.4)	80.9)	74.1)
3	1	29th May	85.5)	81.8)	78.3)	72.3)
	2		84.9)	82.3)	73.5)	68.2)
	3		85.7)85.3	81.1)81.8	74.6)75.9	70.8)69.8
	4		85.6)	82.8	77.5)	67.6)
	5		84.9)	81.0)	75.7)	70.0)
4	1	9th June	81.6)	74.7)	71.8)	68.9)
	2		83.2)	76.8)	71.9)	72.0)
	3		83.8)82.8	76.9)76.2	73.8)70.9	71.5)70.2
	4		83.7)	77.6)	68.7)	71.1)
	5		81.6)	74.8)	68.5)	67.6)
5	1	12th June	81.5)	76.2)	70.3)	71.8)
	2		81.9)	74.5)	69.9)	71.8)
	3		82.5)82.2	76.2)77.0	71.8)72.7	73.6)73.2
	4		82.6)	77.9)	75.8)	74.3)
	5		82.4)	80.1)	75.6)	74.7)
Combined Averages			84.7	81.2	76.7	73.5

(contd.)

APPENDIX 6 contd.

Percentage Moisture Contents of Fresh and Wilted Grass-Clover Herbages - 1954 Wilting Trials.

Trial Number	Replicate Numbers	Date	Fresh Herbage	18 hours wilting	21 hours wilting	24 hours wilting
LONG PERIOD WILTING						
6	1	19th-20th May	84.7)	80.3)	78.2)	74.9)
	2		84.6)	80.1)	77.4)	72.6)
	3		83.2)84.3	79.1)79.5	75.5)76.8	68.5)72.3
	4		84.3)	80.4)	77.8)	74.6)
	5		84.7)	77.6)	75.3)	70.9)
7	1	27th-28th May	84.6)	87.6)	85.9)	84.3)
	2		84.6)	87.5)	84.9)	83.7)
	3		85.2)84.9	86.6)87.0	85.5)85.6	84.1)84.2
	4		84.9)	85.6)	85.5)	84.5)
	5		85.1)	87.5)	86.1)	84.3)
8	1	10th-11th June	86.8)	86.8)	84.5)	82.6)
	2		87.6)	86.6)	84.8)	82.7)
	3		86.2)86.7	85.7)86.5	85.4)84.9	81.4)82.1
	4		86.3)	86.1)	84.9)	81.9)
	5		86.6)	87.2)	84.7)	81.7)
Combined Averages			85.3	84.3	82.4	79.5
				3 hours	6 hours	9 hours
SHORT PERIOD WILTING						
6	1	20th May	85.7)	84.6)	82.1)	77.0)
	2		84.1)	83.5)	79.7)	77.9)
	3		85.3)85.1	83.7)83.9	80.8)81.3	76.5)77.6
	4		85.3)	84.3)	81.3)	78.2)
	5		85.1)	83.5)	82.5)	78.5)
7	1	28th May	88.2)	85.2)	84.1)	83.2)
	2		87.1)	85.0)	84.5)	82.6)
	3		87.1)87.4	84.3)84.9	82.8)84.2	81.9)83.0
	4		87.1)	83.8)	84.1)	82.9)
	5		87.5)	86.0)	85.3)	84.6)
8	1	11th June	86.1)	83.5)	81.1)	78.7)
	2		85.4)	82.9)	80.9)	78.2)
	3		85.4)85.6	82.9)83.2	79.8)80.5	77.0)77.8
	4		84.7)	83.3)	79.7)	76.5)
	5		86.2)	83.4)	80.8)	78.8)
Combined Averages			86.0	84.0	82.0	79.5

APPENDIX 7

Progressive Drop or Rise in per cent Units of Moisture in Grass-Clover Herbage - 1953 Wilting Trials.

(F = fresh crop; A = after 18 hrs wilting; B = after 21 hrs wilting; C = after 24 hrs wilting.)

LONG PERIOD WILTING						
Trial Number	Replicate Number	Date	F - A	A - B	B - C	Total Drop F - C
1	1	14th-15th May	+5)	-1.9)	-4.8)	-1.7)
	2		+1.6)	-6.6)	-0.9)	-5.9)
	3		+1.4)+1.9	-4.8)-5.6	-2.9)-2.8	-6.3)-6.5
	4		+0.8)	-8.9)	-2.1)	-10.2)
	5		+0.7)	-5.9)	-3.4)	-8.6)
2	1	21st-22nd May	-1.8)	-1.7)	-6.1)	-9.6)
	2		-0.5)	-5.0)	-6.0)	-11.5)
	3		+0.3)-1.9	-5.1)-2.8	-8.5)-5.8	-13.3)-10.6
	4		-1.4)	-3.1)	-6.0)	-10.5)
	5		-6.2)	+0.7)	-2.6)	-8.1)
3	1	28th-29th May	-9.2)	-1.6)	-2.1)	-12.9)
	2		-6.0)	-4.4)	-5.1)	-15.5)
	3		-5.8)-7.2	-5.4)-3.9	-0.6)-2.6	-11.8)-13.8
	4		-7.2)	-5.1)	-3.0)	-15.3)
	5		-8.0)	-3.2)	-2.2)	-13.4)
4	1	8th-9th June	-4.0)	-2.8)	-6.9)	-13.7)
	2		-3.9)	-3.6)	-5.1)	-12.6)
	3		-3.6)-3.4	-5.7)-3.1	-3.7)-6.3	-13.0)-12.9
	4		-2.9)	-1.1)	-9.0)	-13.0)
	5		-2.8)	-2.2)	-7.0)	-12.0)
5	1	11th-12th June	-4.6)	-5.5)	-6.1)	-16.2)
	2		-2.6)	-5.5)	-5.6)	-13.7)
	3		-6.3)-4.6	-2.1)-3.6	-5.3)-6.3	-13.7)-14.5
	4		-5.0)	-2.1)	-6.9)	-14.0)
	5		-4.5)	-2.8)	-7.7)	-15.0)
Combined averages			-3.1	-3.8	-4.8	-11.7

(contd.)

APPENDIX 7 contd.

Progressive Drop or Rise in per cent Units of Moisture in Grass-Clover Herbage - 1953 Wilting Trials.

(F = fresh crop; A = after 3 hrs wilting; B = after 6 hrs wilting; C = after 9 hrs wilting.)

SHORT PERIOD WILTING						
Trial Number	Replicate Number	Date	F - A	A - B	B - C	Total Drop F - C
1	1	15th May	-2.1)	-4.5)	±0.0)	-6.6)
	2		-4.0)	-2.4)	-4.5)	-10.9)
	3		-3.9)-3.4	-4.6)-3.7	-1.6)-2.1	-10.1)-9.2
	4		-2.6)	-5.8)	-1.6)	-10.0)
	5		-4.6)	-1.0)	-2.7)	-8.3)
2	1	22nd May	-2.2)	-1.3)	-5.8)	-9.3)
	2		+2.1)	-4.2)	-7.9)	-10.0)
	3		+2.5)+1.2	-4.8)-3.6	-10.8)-7.8	-13.1)-10.1
	4		+2.7)	-3.0)	-7.8)	-8.1)
	5		+1.1)	-4.5)	-6.8)	-10.2)
3	1	29th May	-3.7)	-3.5)	-6.0)	-13.2)
	2		-2.6)	-8.8)	-5.3)	-16.7)
	3		-4.6)-3.5	-6.5)-5.9	-3.8)-6.1	-14.9)-15.5
	4		-2.8)	-5.3)	-9.9)	-18.0)
	5		-3.9)	-5.3)	-5.7)	-14.9)
4	1	9th June	-6.9)	-2.9)	-2.9)	-12.7)
	2		-6.4)	-4.9)	+0.1)	-11.2)
	3		-6.9)-6.6	-3.1)-5.2	-2.3)-0.7	-12.3)-12.6
	4		-6.1)	-8.9)	+2.4)	-12.6)
	5		-6.8)	-6.3)	-0.9)	-14.0)
5	1	12th June	-5.3)	-5.9)	+1.5)	-9.7)
	2		-7.4)	-4.6)	+1.9)	-10.1)
	3		-6.3)-5.2	-4.4)-4.3	+1.8)+0.6	-8.9)-8.9
	4		-4.7)	-2.1)	-1.5)	-8.3)
	5		-2.3)	-4.5)	-0.9)	-7.7)
Combined averages			-3.5	-4.5	-3.2	-11.2

(contd.)

APPENDIX 7 contd.

Progressive Drop or Rise in per cent Units of Moisture in Grass-Clover Herbage - 1954 Wilting Trials.

(F = fresh crop; A = after 18 hrs wilting; B = after 21 hrs wilting; C = after 24 hrs wilting.)

Trial Number	Replicate Number	Date	F - A	A - B	B - C	Total Drop F - C
LONG PERIOD WILTING						
6	1	19th-20th May	-4.4)	-2.1)	-3.3)	-9.8)
	2		-4.5)	-2.7)	-4.8)	-12.0)
	3		-4.1) -4.8	-3.6) -2.7	-7.0) -4.5	-14.7) -12.0
	4		-3.9)	-2.6)	-3.2)	-9.7)
	5		-7.1)	-2.3)	-4.4)	-13.8)
7	1	27th-28th May	+3.0)	-1.7)	-1.6)	-0.3)
	2		+2.9)	-2.6)	-1.2)	-0.9)
	3		+1.4) +2.1	-1.1) -1.4	-1.4) -1.4	-1.1) -0.7
	4		+0.7)	-0.1)	-1.0)	-0.4)
	5		+2.4)	-1.4)	-1.8)	-0.8)
8	1	10th-11th June	±0.0)	-2.3)	-1.9)	-4.2)
	2		-1.0)	-1.8)	-2.1)	-4.9)
	3		-0.5) -0.2	-0.3) -1.6	-4.0) -2.8	-4.8) -4.6
	4		-0.2)	-1.2)	-3.0)	-4.4)
	5		+0.6)	-2.5)	-3.0)	-4.9)
Combined averages			-1.0	-1.9	-2.9	-5.8
SHORT PERIOD WILTING (F = fresh crop; A = after 3 hrs wilting; B = after 6 hrs wilting; C = after 9 hrs wilting.)						
6	1	20th May	-1.1)	-2.5)	-5.1)	-8.7)
	2		-0.6)	-3.8)	-1.8)	-6.2)
	3		-1.6) -1.2	-2.9) -2.6	-4.3) -3.7	-8.8) -7.5
	4		-1.0)	-3.0)	-3.1)	-7.1)
	5		-1.6)	-1.0)	-4.0)	-6.6)
7	1	28th May	-3.0)	-1.1)	-0.9)	-5.0)
	2		-2.1)	-0.5)	-1.9)	-4.5)
	3		-2.8) -2.5	-1.5) -0.7	-0.9) -1.1	-5.2) -4.4
	4		-3.3)	+0.3)	-1.2)	-4.2)
	5		-1.5)	-0.7)	-0.7)	-2.9)
8	1	11th June	-2.6)	-2.4)	-2.4)	-7.4)
	2		-2.5)	-2.0)	-2.7)	-7.2)
	3		-2.5) -2.4	-3.1) -2.7	-2.8) -2.6	-8.4) -7.7
	4		-1.4)	-3.6)	-3.2)	-8.2)
	5		-2.8)	-2.6)	-2.0)	-7.4)
Combined averages			-2.0	-2.0	-2.5	-6.5

APPENDIX 8

Fresh and Dry Weights of Samples of Grass-Clover Herbage used for the 1953 Wilting Trials

Trial Number	Replicate Number	Date	LONG PERIOD WILTING											
			ORIGINAL MATERIAL			WILTED 18 HOURS			WILTED 21 HOURS			WILTED 24 HOURS		
			Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.
1	1	14th-15th May	463	83	380	340	44	296	359	53	306	179	35	144
	2		384	60	324	314	44	270	204	42	162	158	34	124
	3		360	52	308	385	50	335	343	61	282	261	54	207
	4		255	40	215	195	29	166	147	35	112	85	22	63
	5		238	36	202	160	23	137	143	29	114	114	27	87
2	1	21st-22nd May	465	69	396	482	80	402	481	88	393	316	77	239
	2		320	46	274	496	74	422	497	99	398	344	89	255
	3		428	67	361	305	47	258	292	60	232	214	62	152
	4		325	46	279	405	63	342	369	69	300	239	59	180
	5		296	53	243	245	59	186	299	70	229	208	54	154
3	1	28th-29th May	467	74	393	360	90	270	346	92	254	355	102	253
	2		566	83	483	653	135	518	609	153	456	268	81	187
	3		564	88	476	462	99	363	354	95	259	449	123	326
	4		645	106	539	492	116	376	342	98	244	303	96	207
	5		386	70	316	249	65	184	256	75	181	213	67	146
4	1	8th-9th June	605	106	499	554	119	435	511	124	387	433	135	298
	2		869	162	707	445	100	345	499	130	369	468	146	322
	3		683	115	568	550	112	438	337	88	249	349	104	245
	4		579	114	465	572	129	443	489	116	373	401	131	270
	5		486	89	397	536	113	423	610	142	468	498	151	347
5	1	11th-12th June	502	94	408	648	150	498	496	143	353	393	137	256
	2		463	89	374	579	126	453	543	148	395	423	139	284
	3		512	104	408	572	152	420	477	137	340	400	136	264
	4		654	109	545	516	112	404	449	107	342	387	119	268
	5		544	102	442	574	133	441	539	140	399	374	126	248

(contd.)

Fresh and Dry Weights of Samples of Grass-Clover Herbage used for the 1953 Wilting Trials

SHORT PERIOD WILTING

Trial Number	Replicate Number	Date	ORIGINAL HERBAGE			WILTED 3 HOURS			WILTED 6 HOURS			WILTED 9 HOURS		
			Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.
1	1	15th May	480	63	417	434	66	368	295	58	237	290	57	233
	2		341	41	300	324	52	272	315	58	257	179	41	138
	3		336	38	298	257	39	218	298	59	239	257	55	202
	4		394	49	345	327	49	278	259	54	205	245	55	190
	5		244	36	208	191	37	154	201	41	160	121	28	93
2	1	22nd May	544	69	475	476	61	415	462	75	387	437	96	341
	2		471	65	406	494	58	436	548	87	461	269	64	205
	3		371	50	321	502	55	447	520	82	438	259	69	190
	4		366	51	315	554	62	492	445	63	382	254	56	198
	5		350	55	295	322	47	275	304	58	246	247	64	183
3	1	29th May	738	107	631	738	134	604	488	106	382	329	91	238
	2		855	129	726	469	83	386	302	80	222	245	78	167
	3		463	66	397	403	76	327	409	104	305	284	83	201
	4		648	93	555	548	94	454	404	91	313	225	73	152
	5		491	74	417	559	106	453	329	80	249	290	87	203
4	1	9th June	669	123	546	510	129	381	419	118	301	338	105	233
	2		613	103	510	535	124	411	423	119	304	403	113	290
	3		771	125	646	563	130	433	596	156	440	389	111	278
	4		762	124	638	678	152	526	355	111	244	505	146	359
	5		718	132	586	523	132	391	480	151	329	377	122	255
5	1	12th June	449	83	366	404	96	308	343	102	241	255	72	183
	22		507	92	415	415	106	309	356	107	249	401	113	288
	3		497	87	410	341	81	260	305	86	219	307	81	226
	4		447	78	369	456	101	355	363	88	375	400	103	297
	5		535	94	441	433	86	347	353	86	267	336	85	251

(contd.)

Fresh and Dry Weights of Samples of Grass-Clover Herbage used for the 1954 Wilting Trials.

LONG PERIOD WILTING													
Trial Number	Replicate Number	Date	ORIGINAL HERBAGE			WILTED 18 HOURS			WILTED 21 HOURS			WILTED 24 HOURS		
			Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.
6	1	19th-20th May	235	36	199	208	41	167	229	50	179	195	49	146
	2		292	45	247	317	63	254	155	35	120	124	34	90
	3		155	26	129	115	24	91	110	27	83	124	39	85
	4		351	55	296	245	48	197	203	45	158	201	51	150
	5		202	31	171	125	28	97	154	38	116	110	32	78
7	1	27th-28th May	423	65	358	330	41	289	396	56	340	324	51	273
	2		325	50	275	296	37	259	299	45	254	257	42	215
	3		270	40	230	298	40	258	207	30	177	314	50	264
	4		383	58	325	520	75	445	434	63	371	310	48	262
	5		350	52	298	369	46	323	302	42	260	305	48	257
8	1	10th-11th June	462	61	401	531	70	461	466	72	394	414	72	342
	2		443	55	388	403	54	349	401	61	340	311	54	257
	3		493	68	425	399	57	342	391	57	334	280	52	228
	4		489	67	422	402	56	346	350	53	297	326	59	267
	5		409	55	354	392	50	342	392	60	332	219	40	179

(contd.)

Fresh and Dry Weights of Samples of Grass-Clover Herbage used for the 1954 Wilting Trials.

SHORT PERIOD WILTING													
Trial Number	Replicate Number	Date	ORIGINAL HERBAGE			WILTED 3 HOURS			WILTED 6 HOURS			WILTED 9 HOURS		
			Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.	Fresh gm.	Oven Dried gm.	Diff. gm.
6	1	20th May	357	51	306	285	44	241	190	34	156	148	34	114
	2		340	54	286	230	38	192	256	52	204	190	42	148
	3		292	43	249	257	42	215	167	32	135	213	50	163
	4		224	33	191	248	39	209	171	32	139	174	38	136
	5		249	37	212	273	45	228	286	50	236	200	43	157
7	1	28th May	474	56	418	337	50	287	364	58	306	322	54	268
	2		419	54	365	400	60	340	399	62	337	287	50	237
	3		326	42	284	305	48	257	233	40	193	248	45	203
	4		381	49	332	321	52	269	433	69	364	315	54	261
	5		481	60	421	421	59	362	348	51	297	311	48	263
8	1	11th June	467	65	402	334	55	279	297	56	241	258	55	203
	2		608	89	519	422	72	350	391	75	316	252	55	197
	3		390	57	333	286	49	237	277	56	221	248	57	191
	4		557	85	472	436	73	363	419	85	334	293	69	224
	5		574	79	495	452	75	377	313	60	253	269	57	212

APPENDIX 9.

Relative Increases in Dry Matter Content of Wilted Grass-Clover Herbage 1953 and 1954 Wilting Trials.

LONG PERIOD WILTING	(dry matter content of fresh herbage expressed as 100)							
Treatment	1953 Trials					1954 Trials		
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
Fresh crop	100	100	100	100	100	100	100	100
After 18 hr. wilting	88	112	145	119	125	131	86	102
After 21 " "	124	131	170	136	144	148	95	114
After 24 " "	142	169	186	170	178	176	105	135
SHORT PERIOD WILTING								
Fresh crop	100	100	100	100	100	100	100	100
after 3 hr. wilting	128	91	124	138	129	108	120	117
after 6 hr. wilting	156	117	164	169	153	126	125	135
after 9 hr. wilting	172	173	205	173	151	150	135	154

APPENDIX 10

Moisture Content of Grass-Clover Swathes left lying overnight - 1954 Trials.

Trial Number	Replicate Number	Date	FRESHLY CUT HERBAGE Fresh Weight gm.	Dry Weight gm.	Diff. gm.	Moisture %	AFTER TWELVE HOURS EXPOSURE Fresh Weight gm.	Dry Weight gm.	Diff. gm.	Moisture Content %
1	1	12th-13th May	207	32	175	84.5	253	34	219	86.6
	2		133	23	110	82.7	163	24	139	85.3
	3		238	39	199	83.6	270	36	234	86.7
	4		200	34	166	83.0	218	29	189	86.7
	5		213	33	180	84.5	259	32	227	87.6
			Average Moisture Content			83.7	Average Moisture Content			86.6
2	1	17th-18th May	162	30	132	81.5	167	29	138	82.6
	2		275	47	228	82.9	233	38	195	83.7
	3		243	46	197	81.1	197	35	162	82.2
	4		243	44	199	81.9	254	43	211	83.1
	5		318	52	266	83.6	221	35	186	84.2
			Average Moisture Content			82.2	Average Moisture Content			83.2
3	1	19th-20th May	321	53	268	83.5	243	43	200	82.3
	2		354	54	300	84.7	289	47	242	83.7
	3		290	45	245	84.5	181	30	151	83.4
	4		307	51	256	83.4	243	42	201	82.7
	5		303	49	254	83.8	244	41	203	83.2
			Average Moisture Content			84.0	Average Moisture Content			83.1
4	1	27th-28th May	503	70	433	86.1	624	70	554	88.8
	2		405	63	342	84.4	592	69	523	88.3
	3		566	77	489	86.4	616	69	547	88.8
	4		476	64	412	86.6	757	81	676	89.3
	5		473	72	401	84.8	499	64	435	87.2
			Average Moisture Content			85.7	Average Moisture Content			88.5
5	1	11th-12th June	420	70	350	83.3	401	64	337	84.0
	2		357	55	302	84.6	548	83	465	84.9
	3		449	72	377	84.0	412	64	348	84.5
	4		391	57	334	85.4	489	75	414	84.7
	5		387	66	321	82.9	540	85	455	84.3
			Average Moisture Content			84.0	Average Moisture Content			84.5
6	1	15th-16th June (1955)	658	146	512	77.8	543	143	400	73.7
	2		712	145	567	79.6	544	134	410	75.4
	3		570	118	452	79.3	613	160	453	73.9
	4		607	139	468	77.1	580	136	444	76.6
	5		472	109	363	76.9	418	115	303	72.5
			Average Moisture Content			78.1	Average Moisture Content			74.4

APPENDIX 11

Moisture Changes in Standing Grass - Clover Herbage - 1954 Trials

(Each result is a mean of ten samples)

Trial Number	Date	Time of Day	Fresh Weight gm.	Dry Weight gm.	Diff. gm.	Moisture %	Trial Number	Date	Time of Day	Fresh Weight gm.	Dry Weight gm.	Diff. gm.	Moisture Content %
1	20th May	7.15 a.m.	411	65	346	84.2	5	20th July	7.00 a.m.	501	102	399	79.6
		10.15 a.m.	371	57	314	84.6			10.00 a.m.	478	109	369	77.2
		1.15 p.m.	424	71	353	83,3			1.00 p.m.	434	105	329	75.8
		4.15 p.m.	377	63	314	83.3			4.00 p.m.	393	94	299	76.1
2	24th May	7.45 a.m.	382	54	328	85.9	6	29th July	7.00 a.m.	611	110	501	82.0
		10.45 a.m.	473	73	400	84.6			10.00 a.m.	515	109	406	78.8
		1.45 p.m.	432	68	364	84.3			1.00 p.m.	537	120	417	77.7
		4.45 p.m.	455	61	394	86.6			4.00 p.m.	562	132	430	76.5
3	28th May	7.45 p.m.	721	89	632	87.7	7	31st July	7.00 a.m.	513	105	408	79.5
		11.15 a.m.	642	86	556	86.6			10.00 a.m.	579	122	457	78.9
		1.45 p.m.	586	82	504	86.0			1.00 p.m.	669	148	521	77.9
		4.35 p.m.	703	94	609	86.6			4.00 p.m.	550	124	426	77.5
4	16th July	7.00 a.m.	364	81	283	77.7	8	4th August	7.15 a.m.	561	108	453	80.7
		10.00 a.m.	344	81	263	76.5			10.15 a.m.	516	116	400	77.5
		1.00 p.m.	435	105	330	75.9			1.15 p.m.	447	104	343	76.7
		4.00 p.m.	347	83	264	76.1			4.15 p.m.	450	107	343	76.2

APPENDIX 12

1954 Cutting Trials - Randomised Plots

A plots cut at 6.30 a.m.
B plots cut at 9.30 a.m.
C plots cut at 12.30 p.m.
D plots cut at 3.30 p.m.

Sub-plots collected at 2 hourly intervals

Cutting Trial 1

A	B	D	C	D	B	C	A	B	D	C	A
6.30 a.m.	3.30 p.m.	-	-	3.30 p.m.	9.30 a.m.	6.30 p.m.	4.30 p.m.	1.30 p.m.	-	-	12.30 p.m.
12.30 p.m.	11.30 a.m.	3.30 p.m.	12.30 p.m.	7.30 p.m.	7.30 p.m.	-	6.30 a.m.	3.30 p.m.	5.30 p.m.	4.30 p.m.	8.30 a.m.
4.30 p.m.	5.30 p.m.	5.30 p.m.	4.30 p.m.	-	11.30 a.m.	2.30 p.m.	12.30 p.m.	-	-	-	10.30 a.m.
8.30 a.m.	7.30 p.m.	-	2.30 p.m.	-	3.30 p.m.	4.30 p.m.	10.30 a.m.	7.30 p.m.	3.30 p.m.	-	4.30 p.m.
6.30 p.m.	-	7.30 p.m.	-	5.30 p.m.	-	-	2.30 p.m.	5.30 p.m.	-	6.30 p.m.	6.30 a.m.
10.30 a.m.	1.30 p.m.	-	-	-	5.30 p.m.	-	6.30 p.m.	9.30 a.m.	-	2.30 p.m.	6.30 p.m.
2.30 p.m.	9.30 a.m.	-	6.30 p.m.	-	1.30 p.m.	12.30 p.m.	8.30 a.m.	11.30 a.m.	7.30 p.m.	12.30 p.m.	2.30 p.m.
A	B	D	C	D	B	C	A	B	D	C	A

Cutting Trial 2

C	B	B	A	D	C	B	A	D	C	D	A
2.30 p.m.	11.30 a.m.	9.30 a.m.	10.30 a.m.	3.30 p.m.	4.30 p.m.	11.30 a.m.	2.30 p.m.	-	- -	7.30 p.m.	12.30 p.m.
4.30 p.m.	3.30 p.m.	7.30 p.m.	4.30 p.m.	-	2.30 p.m.	3.30 p.m.	10.30 a.m.	7.30 p.m.	4.30 p.m.	-	2.30 p.m.
-	5.30 p.m.	-	6.30 p.m.	7.30 p.m.	12.30 p.m.	7.30 p.m.	8.30 a.m.	5.30 p.m.	-	-	10.30 a.m.
12.30 p.m.	9.30 a.m.	11.30 a.m.	12.30 p.m.	-	-	1.30 p.m.	12.30 p.m.	-	6.30 p.m.	3.30 p.m.	4.30 p.m.
-	7.30 p.m.	5.30 p.m.	6.30 a.m.	-	-	5.30 p.m.	6.30 p.m.	-	12.30 p.m.	-	8.30 a.m.
6.30 p.m.	-	1.30 p.m.	2.30 p.m.	-	-	-	4.30 p.m.	3.30 p.m.	2.30 p.m.	-	6.30 a.m.
-	1.30 p.m.	3.30 p.m.	8.30 a.m.	5.30 p.m.	6.30 p.m.	9.30 a.m.	6.30 a.m.	-	-	5.30 p.m.	6.30 p.m.
C	B	B	A	D	C	B	A	D	C	D	A

(contd.)

APPENDIX 12 (contd.)

Meteorological Data - 1954 Cutting Trials

Time of Day	Wet Bulb °F	Dry Bulb °F	Relative Humidity %	Saturation Deficit mm/Hg
CUTTING TRIAL 1 - 16th JULY				
6 a.m.	50	52	87	1.4
8 a.m.	51	54	82	1.9
10 a.m.	52	56	76	2.8
12 noon	55	60	73	3.6
2 p.m.	55	60	73	3.6
4 p.m.	53	58	72	3.4
6 p.m.	53	56	82	2.0
8 p.m.	55	57	88	1.5
CUTTING TRIAL 2 - 20th JULY				
6 a.m.	55	56	94	0.7
8 a.m.	56	58	88	1.5
10 a.m.	54	57	82	2.0
12 noon	53	59	67	4.0
2 p.m.	53	59	67	4.0
4 p.m.	53	58	72	3.4
6 p.m.	53	59	67	4.0
8 p.m.	51	57	66	3.9

(contd.)

APPENDIX 12 (contd)

Moisture contents of Grass-Clover Herbage used for 'Cutting Trial' 1

16th July, 1954

Plot Cutting Time	Sub-plot Sampling Time	Fresh Weight gm.	Dry Weight gm.	Diff. gm.	Moisture Content %	Average Moisture Content %
A Plots cut at 6.30 a.m.	6.30 a.m.	415	97	318	76.6	76.9
	"	568	129	439	77.3	
	"	454	106	348	76.7	
	8.30 a.m.	424	105	319	75.2	75.7
	"	389	95	294	75.6	
	"	518	122	396	76.4	
	10.30 a.m.	481	134	347	72.1	73.5
	"	416	109	307	73.8	
	"	347	88	259	74.6	
	12.30 p.m.	360	113	247	68.6	67.8
	"	343	104	239	69.7	
	"	377	132	245	65.0	
	2.30 p.m.	320	134	186	58.1	60.9
	"	323	121	202	62.5	
	"	270	102	168	62.2	
	4.30 p.m.	405	156	249	61.5	61.1
	"	298	125	173	58.1	
	"	226	82	144	63.7	
	6.30 p.m.	370	151	219	59.2	60.4
	"	172	71	101	58.7	
	"	199	73	126	63.3	
B Plots cut at 9.30 a.m.	9.30 a.m.	367	89	278	75.7	75.1
	"	398	100	298	74.9	
	"	452	114	338	74.8	
	11.30 a.m.	460	131	329	71.5	71.6
	"	484	133	351	72.5	
	"	522	152	370	70.9	
	1.30 p.m.	306	116	190	62.1	63.3
	"	270	99	171	63.3	
	"	320	114	206	64.4	
	3.30 p.m.	386	150	236	61.1	62.5
	"	351	124	227	64.7	
	"	274	105	169	61.7	
	5.30 p.m.	357	132	225	63.0	61.0
	"	252	103	149	59.1	
	"	304	119	185	60.9	
	7.30 p.m.	273	110	163	59.7	60.2
	"	240	98	142	59.2	
	"	246	94	152	61.8	
C Plots cut at 12.30 p.m.	12.30 p.m.	389	97	292	75.1	75.5
	"	409	103	306	74.8	
	"	443	104	339	76.5	
	2.30 p.m.	362	112	250	69.1	70.1
	"	409	120	289	70.7	
	"	403	119	284	70.5	
	4.30 p.m.	295	101	194	65.7	64.8
	"	321	109	212	66.0	
	"	301	112	189	62.8	
	6.30 p.m.	472	174	298	63.1	64.2
	"	304	110	194	63.8	
	"	292	100	192	65.8	
D Plots cut at 3.30 p.m.	3.30 p.m.	443	111	332	74.9	75.1
	"	435	112	323	74.3	
	"	341	81	260	76.2	
	5.30 p.m.	503	126	377	75.00	73.6
	"	473	131	342	72.3	
	"	407	108	299	73.5	
	7.30 p.m.	357	106	251	70.3	70.2
	"	342	102	240	70.2	
	"	403	121	282	70.0	

APPENDIX 12

Moisture contents of Grass-Clover Herbage used for 'Cutting Trial' 2

20th July, 1954

Plot Cutting Time	Sub-plot Sampling Time	Fresh Weight gm.	Dry Weight gm.	Diff. gm.	Moisture Content %	Average Moisture Content %
Plots 'A' cut at 6.30 a.m.	6.30 a.m.	522	101	421	80.7	80.8
	"	573	108	465	81.2	
	"	664	129	535	80.6	
	8.30 a.m.	684	144	540	78.9	79.7
	"	670	128	542	80.9	
	"	577	120	457	79.2	
	10.30 a.m.	704	179	525	74.60	75.6
	"	544	124	420	77.2	
	"	498	125	373	74.9	
	12.30 p.m.	455	136	319	70.1	70.6
	"	439	121	318	72.4	
	"	512	157	355	69.3	
	2.30 p.m.	393	126	267	67.9	67.0
	"	454	156	298	65.6	
	"	481	156	325	67.6	
	4.30 p.m.	475	171	304	64.0	65.1
	"	387	133	254	65.6	
	"	341	117	224	65.7	
	6.30 p.m.	333	124	209	62.8	60.3
	"	294	113	181	61.6	
	"	329	143	186	56.5	
Plots 'B' cut at 9.30 a.m.	9.30 a.m.	607	128	479	78.9	77.2
	"	646	156	490	75.9	
	"	502	116	386	76.9	
	11.30 a.m.	535	155	380	71.0	72.8
	"	637	170	467	73.3	
	"	596	154	442	74.2	
	1.30 p.m.	381	116	265	69.6	69.7
	"	401	121	280	69.8	
	"	444	134	310	69.8	
	3.30 p.m.	487	157	330	67.8	67.4
	"	417	144	273	65.5	
	"	449	139	310	69.0	
	5.30 p.m.	482	162	320	66.4	63.1
	"	349	139	210	60.2	
	"	359	134	225	62.7	
	7.30 p.m.	314	131	183	58.3	58.4
	"	277	117	160	57.8	
	"	289	118	171	59.2	
Plots 'C' cut at 12.30 p.m.	12.30 p.m.	627	154	473	75.4	75.8
	"	690	163	527	76.4	
	"	466	114	352	75.5	
	2.30 p.m.	369	115	254	68.8	71.2
	"	503	134	369	73.4	
	"	315	90	225	71.4	
	4.30 p.m.	386	124	262	67.9	67.2
	"	331	110	221	66.8	
	"	349	115	234	67.0	
	6.30 p.m.	484	182	302	62.4	63½1
	"	388	143	245	63.1	
	"	290	105	185	63.8	
Plots 'D' cut at 3.30 p.m.	3.30 p.m.	611	143	468	76.6	75.5
	"	531	131	400	75.3	
	"	435	111	324	74.5	
	5.30 p.m.	377	114	263	69.8	71.2
	"	462	129	333	72.1	
	"	401	114	287	71.6	
	7.30 p.m.	442	144	298	67.4	66.2
	"	429	141	288	67.1	
	"	366	131	235	64.2	

APPENDIX 13

Layout of Grass-Clover Swathes for the 1954 Bruising - Wilting trials

Sections of swathes For Ordinary Moisture Determinations

Sections of swathes For Examining Upper and Lower Portions of Swathe

Sections of swathes For Calculation of Losses due to Wilting

TRIAL 9 24th May	Mown Swathe	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Bruised Swathe	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TRIAL 10 29th July	Mown Swathe	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Bruised Swathe	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TRIAL 11 31st July	Mown Swathe	1	2	3	4	5	6	7	8	99	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Bruised Swathe	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TRIAL 12 4th August	Mown Swathe	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Bruised Swathe	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

← 35 yd. →

(contd.)

APPENDIX 13 (contd.)

Meteorological Data - 1954 Bruising - Wilting Trials

Trial Number	Date	Time	Wet Bulb °F.	Dry Bulb °F	Relative Humidity %	Saturation Deficit mm/Hg.
9	24th May	6.00 a.m.	43	44	93	0.5
		9.00 a.m.	45	47	86	1.2
		12.00 noon	46	50	74	2.4
		1.30 p.m.	47	50	80	1.9
		3.00 p.m.	49	52	81	1.9
		6.00 p.m.	50	52	87	1.4
10	29th July	6.00 a.m.	51	53	87	1.4
		9.00 a.m.	53	56	82	2.0
		12.00 noon	55	61	68	4.4
		1.30 p.m.	54	58	77	2.9
		3.00 p.m.	54	59	72	3.6
		6.00 p.m.	52	57	71	3.4
11	31st July	6.00 a.m.	48	50	87	1.3
		9.00 a.m.	48	52	75	2.5
		12.00 noon	51	55	76	2.8
		1.30 p.m.	52	55	82	2.0
		3.00 p.m.	52	57	71	3.4
		6.00 p.m.	52	57	71	3.4
12	4th August	6.00 a.m.	46	47	93	0.6
		9.00 a.m.	52	55	82	2.0
		12.00 noon	58	61	84	2.2
		1.30 p.m.	-	-	-	-
		3.00 p.m.	55	63	60	5.9
		6.00 p.m.	54	63	55	6.3

(contd.)

Fresh and Dry Weights and Percentage Moisture Contents of Fresh and Wilted Bruised and Mown Grass-Clover Herbage - 1954 Wilting Trials

Trial Number	Date	Crop Treatment	BRUISED HERBAGE				MOWN HERBAGE			
			Fresh Matter gm.	Dry Matter gm.	Diff. gm.	Moisture Content %	Fresh Matter gm.	Dry Matter gm.	Diff gm.	Moisture Content %
9	24th May	Fresh	824	115	709	86.0	527	74	453	86.0
		Wilted 3 hours	497	78	419	84.3	548	91	457	83.4
		Wilted 6 hours	594	106	488	82.2	536	92	444	82.8
		Wilted 9 hours	531	90	441	83.1	585	96	489	83.6
10	29th July	Fresh	1123	203	920	81.9	910	161	749	82.3
		Wilted 3 hours	769	172	597	77.6	722	164	558	77.3
		Wilted 6 hours	689	201	488	70.8	893	259	634	71.0
		Wilted 9 hours	596	209	387	64.9	731	274	457	62.5
11	31st July	Fresh	723	147	576	79.7	809	169	640	79.1
		Wilted 3 hours	972	243	729	75.0	1072	267	805	75.1
		Wilted 6 hours	1000	291	709	70.9	1209	376	833	68.9
		Wilted 9 hours	876	288	588	67.1	1038	373	665	64.1
12	4th August	Fresh	850	174	676	79.5	1086	219	867	79.8
		Wilted 3 hours	817	219	598	73.2	1313	337	976	74.3
		Wilted 6 hours	807	310	497	61.2	1096	387	709	64.7
		Wilted 9 hours	584	261	323	55.3	819	367	452	55.2

APPENDIX 14

Fresh and Dry Weights and Percentage Moisture Contents of Upper and Lower Portions of Bruised - Wilted and Mown - Wilted Grass - Clover Swathes - 1954 Wilting Trials

Trial Number	Date	Replicate Number	BRUISED HERBAGE							
			TOP OF SWATHE				BOTTOM OF SWATHE			
			Fresh Matter gm.	Dry Matter gm.	Diff. gm.	Moisture Content %	Fresh Matter gm.	Dry Matter gm.	Diff. gm.	Moisture Content %
9	24th May	1	321	76	245	76.3	429	70	359	83.7
		2	407	89	318	78.1	465	70	395	84.9
		3	459	102	357	77.80	454	70	384	84.6
		4	397	91	306	77.1	442	69	373	84.4
		5	303	74	229	75.6	426	67	359	84.3
10	29th July	1	165	105	60	36.4	335	107	228	68.1
		2	220	138	82	37.3	458	171	287	62.7
		3	114	66	48	42.1	223	60	163	73.1
		4	223	123	100	44.8	337	74	263	78.0
		5	246	140	106	43.1	415	99	316	76.1
11	31st July	1	190	104	86	45.3	374	97	277	74.1
		2	189	105	84	44.4	384	110	274	71.4
		3	186	100	86	46.2	308	82	226	73.4
		4	212	113	99	46.7	430	120	310	72.1
		5	239	124	115	48.1	448	122	326	72.8
12	4th August	1	122	91	31	25.4	179	79	100	55.9
		2	125	94	31	24.8	210	117	93	44.3
		3	112	86	26	23.2	182	92	90	49.5
		4	123	94	29	23.6	251	105	146	58.2
		5	126	89	37	29.4	446	129	317	71.1
			MOWN HERBAGE							
9	24th May	1	406	72	334	82.3	324	58	266	82.1
		2	484	90	394	81.4	271	46	225	83.0
		3	439	82	357	81.3	363	64	299	82.4
		4	351	59	292	83.2	281	40	241	85.8
		5	395	66	329	83.3	294	45	249	84.7
10	29th July	1	333	156	177	53.2	362	127	235	64.9
		2	255	112	143	56.1	322	115	207	64.3
		3	298	128	170	57.0	282	99	183	64.9
		4	333	136	197	59.2	306	99	207	67.6
		5	402	163	239	59.5	386	134	252	65.3
11	31st July	1	311	122	189	60.8	361	112	249	69.0
		2	203	86	117	57.6	276	96	180	65.2
		3	274	112	162	59.1	318	108	210	66.0
		4	243	97	146	60.1	308	101	207	67.2
		5	314	120	194	61.8	427	136	291	68.1
12	4th August	1	183	96	87	47.5	237	92	145	61.2
		2	158	80	78	49.4	229	92	137	59.8
		3	187	91	96	51.3	299	116	183	61.2
		4	225	104	121	53.8	360	141	219	60.8
		5	264	126	138	52.3	442	177	265	60.0

APPENDIX 15

Fresh Weight Losses due to Wilting of Grass-Clover Herbage - 1953 Trials

LONG PERIOD WILTING - 24 HOURS					SHORT PERIOD WILTING - 9 HOURS				
Trial	Fresh Material gm.	Wilted Material gm.	Loss gm.	Loss %	Trial	Fresh Material gm.	Wilted Material gm.	Loss gm.	Loss %
2	507	316	191	38	2	723	437	286	40
	538	344	194	36		461	269	192	42
	351	214	137	39		446	259	187	42
	390	239	151	39		430	254	176	41
	351	208	143	41		407	247	160	39
			Average	38				Average	41
3	673	355	318	47	3	636	329	307	48
	555	268	287	52		467	245	222	48
	728	449	279	38		564	284	280	50
	563	303	260	46		483	225	258	53
	672	213	459	68		580	290	290	50
			Average	50				Average	50
4	711	433	278	39	4	604	338	266	44
	709	468	241	34		713	403	310	44
	563	349	214	38		719	389	330	46
	663	401	262	40		840	505	335	40
	793	498	295	37		637	377	260	41
			Average	38				Average	43
5	753	393	360	48	5				
	756	423	333	44					
	720	400	320	44					
	681	387	294	43					
	672	374	298	44					
			Average	45					
			Combined Average	43				Combined Average	45

(contd.)

Fresh Weight Losses due to Wilting of Grass-Clover Herbage - 1954 Trials

LONG PERIOD WILTING - 24 HOURS					SHORT PERIOD WILTING - 9 HOURS				
Trial	Fresh Material gm.	Wilted Material gm.	Loss gm.	Loss %	Trial	Fresh Material gm.	Wilted Material gm.	Loss gm.	Loss %
	323	195	128	40		242	148	94	39
	224	124	100	45		293	190	103	35
6	249	124	125	50	6	327	213	114	35
	335	201	134	40		282	174	108	38
	200	110	90	45		317	200	117	37
			Average	44				Average	37
	333	324	9	3		422	322	100	24
	277	257	20	7		388	287	101	26
7	354	314	40	11	7	326	248	78	24
	320	310	10	3		410	315	95	23
	318	305	13	4		399	311	88	22
			Average	6				Average	24
	486	414	72	15		385	258	127	33
	397	311	86	22		372	252	120	32
8	341	280	61	18	8	357	248	109	31
	397	326	71	18		428	293	135	32
	280	219	61	22		398	269	129	32
			Average	19				Average	32
			Combined Average	23				Combined Average	31

(contd.)

Fresh Weight Losses due to Wilting of Bruised and Mown Grass-Clover Herbage - 1954 Trials

BRUISED HERBAGE					MOWN HERBAGE				
SHORT PERIOD WILTING - 9 HOURS					SHORT PERIOD WILTING - 9 HOURS				
Trial	Fresh Material gm.	Wilted Material gm.	Loss gm.	Loss %	Trial	Fresh Material gm.	Wilted Material gm.	Loss gm.	Loss %
	353	227	126	36		424	421	3	1
	592	411	181	31		399	403	+ 4	+ 1
9	927	732	195	21	9	394	402	+ 6	+ 2
	587	425	162	28		408	412	+ 4	+ 1
	701	521	180	26		418	426	+ 8	+ 2
			Average	28				Average	+ 1
	992	379	613	62		744	386	358	48
	831	291	540	65		392	188	204	52
10	1025	402	623	61	10	454	202	252	56
	883	323	560	63		439	204	235	54
	837	303	534	64		450	215	235	52
			Average	63				Average	52
	808	374	434	54		401	243	158	39
	852	396	456	54		367	204	163	44
11	900	387	513	57	11	390	222	168	43
	728	318	410	56		336	176	160	48
	752	341	411	55		411	239	172	42
			Average	55				Average	43
	624	184	440	71		474	249	225	47
	674	213	461	68		424	207	217	51
12	618	224	394	64	12	476	248	228	48
	740	276	464	63		518	275	243	47
	567	210	357	63		377	174	203	54
			Average	66				Average	49
		Combined	Average	53			Combined	Average	36

(contd.)

Dry Matter Losses and Gains due to Wilting of Grass-Clover Herbage - 1953 Trials

LONG PERIOD WILTING - 24 HOURS

Trial	FRESH HERBAGE			WILTED HERBAGE			LOSS or GAIN	
	Fresh Matter gm.	Dry Matter %	Oven Dried Material (a) gm.	Fresh Matter gm.	Dry Matter %	Oven Dried Material (b) gm.	a - b gm.	$\frac{\text{diff.}}{a} \times 100$ %
	507	14.8	75	316	24.4	77	+ 2	+ 3
	538	14.4	77	344	25.9	89	+ 12	+ 16
2	351	15.7	55	214	29.0	62	+ 7	+ 13
	390	14.2	55	239	24.7	59	+ 4	+ 7
	351	17.9	63	208	26.0	54	- 9	- 14
							Average	+ 5
	673	15.8	106	355	28.7	102	- 4	- 4
	555	14.7	82	268	30.2	81	- 1	- 1
3	728	15.6	114	449	27.4	123	+ 9	+ 8
	563	16.4	92	303	31.7	96	+ 4	+ 4
	672	18.1	122	213	31.5	67	-	-
							Average	+ 2
	711	17.5	124	433	31.2	135	+ 11	+ 9
	709	18.6	132	468	31.2	146	+ 14	+ 11
4	563	16.8	95	349	29.8	104	+ 9	+ 9
	663	19.7	131	401	32.7	131	± 0	± 0
	793	18.3	145	498	30.3	151	+ 6	+ 4
							Average	+ 7
	753	18.7	141	393	34.9	137	- 4	- 3
	756	19.2	145	423	32.9	1396	- 6	- 4
5	720	20.3	146	400	34.0	136	- 10	- 7
	681	16.7	114	387	30.7	119	+ 5	+ 4
	672	18.7	126	374	33.7	126	+ 0	+ 0
							Average	- 2
							Combined Average	+ 3

SHORT PERIOD WILTING - 9 HOURS

Trial	FRESH HERBAGE			WILTED HERBAGE			LOSS or GAIN	
	Fresh Matter gm.	Dry Matter %	Oven Dried Material (a) gm.	Fresh Matter gm.	Dry Matter %	Oven Dried Material (b) gm.	a - b gm.	$\frac{\text{diff.}}{a} \times 100$ %
	723	12.7	92	437	22.0	96	+ 4	+ 4
	461	13.8	64	269	23.8	64	± 0	± 0
2	446	13.5	60	259	26.6	69	+ 9	+ 15
	430	13.9	60	254	22.0	56	- 4	- 7
	407	15.7	64	247	25.9	64	± 0	± 0
							Average	+ 2
	636	14.5	92	329	27.7	91	- 1	- 1
	467	15.1	71	245	31.8	78	+ 7	+ 10
3	564	14.3	81	284	29.2	83	+ 2	+ 2
	483	14.4	70	225	32.4	73	+ 3	+ 4
	580	15.1	88	290	30.0	87	- 1	- 1
							Average	+ 3
	604	18.4	111	338	31.1	105	- 6	- 5
	713	16.8	120	403	28.0	113	- 7	- 6
4	719	16.2	116	389	28.5	111	- 5	- 4
	840	16.3	137	505	28.9	150	+ 14	+ 10
	637	18.4	117	377	32.4	122	+ 5	+ 4
							Average	± 0
5								
							Average	
							Combined Average	+ 2

(contd.)

Dry Matter Losses and Gains due to Wilting of Grass-Clover Herbage - 1954 Trials

LONG PERIOD WILTING - 24 HOURS

Trial	FRESH HERBAGE			WILTED HERBAGE			LOSS or GAIN	
	Fresh Matter gm.	Dry Matter %	Oven Dried Material (a) gm.	Fresh Matter gm.	Dry Matter %	Oven Dried Material (b) gm.	a - b gm.	$\frac{\text{diff.}}{a} \times 100$ %
	323	15.3	49	195	25.1	49	± 0	± 0
	224	15.4	34	124	27.4	34	± 0	± 0
6	249	16.8	42	124	31.5	39	- 3	- 7
	335	15.7	53	201	25.4	51	- 2	- 4
	200	15.3	31	110	29.1	32	+ 1	+ 3
							Average	- 2
	333	15.4	51	324	15.7	50	- 1	- 2
	277	15.4	43	257	16.3	42	- 1	- 2
7	354	14.8	52	314	15.9	50	- 2	- 4
	320	15.1	48	310	15.5	48	± 0	± 0
	318	14.9	47	305	15.7	48	+ 1	+ 2
							Average	- 1
	486	13.2	64	414	17.4	72	+ 8	+ 13
	397	12.4	49	311	17.3	54	+ 5	+ 10
8	341	13.8	47	280	18.6	52	+ 5	+ 11
	397	13.7	54	326	18.1	59	+ 5	+ 9
	280	13.4	38	219	18.3	40	+ 2	+ 5
							Average	+ 10
							Combined Average	+ 2

SHORT PERIOD WILTING - 9 HOURS

Trial	FRESH HERBAGE			WILTED HERBAGE			LOSS or GAIN	
	Fresh Matter gm.	Dry Matter gm.	Oven Dried Material (a) gm.	Fresh Matter gm.	Dry Matter %	Oven Dried Material (b) gm.	a - b gm.	$\frac{\text{diff.}}{a} \times 100$ %
	242	14.3	35	148	23.0	34	- 1	- 3
	293	15.9	47	190	22.1	42	- 5	- 11
6	327	14.7	48	213	23.5	50	+ 2	+ 4
	282	14.7	41	174	21.8	38	- 3	- 7
	317	14.9	47	200	21.5	43	- 4	- 9
							Average	- 5
	422	11.8	50	322	16.8	54	+ 4	+ 8
	388	12.9	50	287	17.4	50	± 0	± 0
7	326	12.9	42	248	18.1	45	+ 3	+ 7
	410	12.9	53	315	17.1	54	+ 1	+ 2
	399	12.5	50	311	15.4	48	- 2	- 4
							Average	+ 3
	385	13.9	54	258	21.3	55	+ 1	+ 2
	372	14.6	54	252	21.8	55	+ 1	+ 2
8	357	14.6	52	248	23.0	57	+ 5	+ 10
	428	15.3	65	293	23.5	69	+ 4	+ 6
	398	13.8	55	269	21.2	57	+ 2	+ 4
							Average	+ 5
							Combined Average	+ 1

APPENDIX 15 (contd.)

Dry Matter Losses and Gains due to Wilting of Bruised and Mown Grass-Clover Herbage - 1954 Trials

BRUISED HERBAGE - 9 HOURS WILTING

Trial	FRESH HERBAGE			WILTED HERBAGE			LOSS or GAIN	
	Fresh Matter gm.	Dry Matter %	Oven Dried Material (a) gm.	Fresh Matter gm.	Dry Matter %	Oven Dried Material (b) gm.	a - b gm.	$\frac{\text{diff.}}{a}$ x 100 %
9	353	14.3	50	227	22.9	52	+ 2	+ 4
	592	14.6	86	411	21.4	88	+ 2	+ 2
	927	13.6	126	732	16.7	122	- 4	- 3
	587	15.7	92	425	20.2	86	- 6	- 7
	701	13.8	96	521	19.2	100	+ 4	+ 4
							Average	± 0
10	992	19.2	190	379	49.3	187	- 3	- 2
	831	18.7	155	291	49.1	143	- 12	- 8
	1025	16.8	172	402	42.0	169	- 3	- 2
	883	18.0	159	323	49.2	159	± 0	± 0
	837	19.2	161	303	53.1	161	± 0	± 0
							Average	- 2
11	808	21.2	171	374	43.3	162	- 9	- 5
	852	22.4	191	396	49.2	195	+ 4	+ 2
	900	19.7	177	387	46.0	178	+ 1	+ 1
	728	21.0	153	318	47.8	152	- 1	- 1
	752	18.6	140	341	46.0	157	+ 17	+ 12
							Average	+ 4
12	624	21.1	132	184	67.9	125	- 7	- 5
	674	21.1	142	213	66.7	142	± 0	± 0
	618	21.5	133	224	60.7	136	+ 3	+ 2
	740	19.3	143	276	50.0	138	- 5	- 3
	567	23.4	133	210	52.9	111	- 22	- 17
							Average	- 5
							Combined Average	- 1

MOWN HERBAGE - 9 HOURS WILTING

Trial	FRESH HERBAGE			WILTED HERBAGE			LOSS or GAIN	
	Fresh Matter gm.	Dry Matter %	Oven Dried Material (a) gm.	Fresh Matter gm.	Dry Matter %	Oven Dried Material (b) gm.	a - b gm.	$\frac{\text{diff.}}{a}$ x 100 %
9	424	15.2	64	421	16.2	68	+ 4	+ 6
	399	15.0	60	403	15.1	61	+ 1	+ 2
	394	15.2	60	402	15.4	62	+ 2	+ 3
	408	15.3	62	412	14.8	-61	- 1	- 2
	418	15.1	63	426	16.0	68	+ 5	+ 8
							Average	+ 3
10	744	19.7	147	386	38.3	148	+ 1	+ 1
	392	18.6	73	188	37.8	0 71	- 2	- 3
	454	18.5	84	202	37.6	76	- 8	- 10
	439	19.0	83	204	41.2	84	+ 1	+ 1
	450	17.4	78	215	37.2	80	+ 2	+ 3
							Average	- 2
11	401	21.5	86	243	35.0	85	- 1	- 1
	367	21.1	77	204	39.2	80	+ 3	+ 4
	390	21.0	82	222	37.4	83	+ 1	+ 1
	336	21.2	71	176	40.9	72	+ 1	+ 1
	411	21.1	87	239	38.1	91	+ 4	+ 5
							Average	+ 2
12	474	21.1	100	249	41.4	103	+ 3	+ 3
	424	21.4	91	207	44.0	91	+ 1	+ 1
	4760	23.3	111	248	43.1	107	- 4	- 4
	513	22.2	114	275	41.5	114	± 0	± 0
	377	23.5	89	174	47.1	82	- 7	- 8
							Average	- 2
							Combined Average	+ 1

APPENDIX 16

Variation in Moisture Content in Square Yard Plots of Grass-Clover Herbage

TRIAL 1 - MAY 4th, 1954					
Square yard Plot	Sub-Plot	Fresh Weight gm.	Dry Weight gm.	Diff. gm.	Moisture Content %
1	1	124	25	99	79.8
	2	107	20	87	81.3
	3	225	42	183	81.3
	4	136	27	109	80.1
Difference in per cent. units of moisture					1.5
2	1	149	29	120	80.5
	2	136	27	109	80.1
	3	146	30	116	79.5
	4	130	28	102	78.5
Difference in per cent. units of moisture					2.0
3	1	145	30	115	79.3
	2	102	22	80	78.4
	3	98	20	78	79.6
	4	108	21	87	80.6
Difference in per cent. units of moisture					2.2
4	1	118	25	93	78.8
	2	78	17	61	78.2
	3	125	26	99	79.2
	4	72	17	55	76.4
Difference in per cent. units of moisture					2.8
5	1	168	31	137	81.5
	2	186	35	151	81.2
	3	251	46	205	81.7
	4	178	34	144	80.9
Difference in per cent. units of moisture					0.8
6	1	120	26	94	78.3
	2	196	41	155	79.1
	3	142	28	114	80.3
	4	132	27	105	79.5
Difference in per cent. units of moisture					2.0
7	1	164	33	131	79.9
	2	133	27	106	79.7
	3	135	27	108	80.0
	4	127	26	101	79.5
Difference in per cent. units of moisture					0.5
8	1	182	35	147	80.8
	2	167	33	134	80.2
	3	181	37	144	79.6
	4	162	33	129	79.6
Difference in per cent. units of moisture					1.2
9	1	250	43	207	82.8
	2	230	43	187	81.3
	3	265	48	217	81.9
	4	242	45	197	81.4
Difference in per cent. units of moisture					1.5
10	1	177	37	140	79.1
	2	182	39	143	78.6
	3	145	30	115	79.3
	4	248	48	200	80.6
Difference in per cent. units of moisture					2.0
Average difference in per cent. units of moisture					1.7

APPENDIX 16 (contd.)

Variation in Moisture Content in Square Yard Plots of Grass-Clover Herbage

TRIAL 2 - MAY 7th, 1954					
Square yard Plot	Sub-Plot	Fresh Weight gm.	Dry Weight gm.	Diff. gm.	Moisture Content %
1	1	109	24	85	78.0
	2	93	21	72	77.4
	3	81	19	62	76.5
	4	90	21	69	76.7
Difference in per cent. units of moisture					1.5
2	1	104	23	81	77.9
	2	96	21	75	78.1
	3	63	16	47	74.6
	4	60	15	45	75.0
Difference in per cent. units of moisture					3.5
3	1	69	16	53	76.8
	2	75	19	56	74.7
	3	91	20	71	78.0
	4	118	26	92	78.0
Difference in per cent. units of moisture					3.3
4	1	86	19	67	77.9
	2	112	24	88	78.6
	3	102	23	79	77.5
	4	69	16	53	76.8
Difference in per cent. units of moisture					1.8
5	1	72	16	56	77.8
	2	105	24	81	77.1
	3	117	28	89	76.1
	4	94	20	74	78.7
Difference in per cent. units of moisture					2.6
6	1	138	30	108	78.3
	2	184	44	140	76.1
	3	152	33	119	78.3
	4	139	30	109	78.4
Difference in per cent. units of moisture					2.3
7	1	130	30	100	76.9
	2	80	17	63	78.8
	3	174	38	136	78.2
	4	178	36	142	79.8
Difference in per cent. units of moisture					2.9
8	1	138	28	110	79.7
	2	165	33	132	80.0
	3	177	34	143	80.8
	4	183	36	147	80.3
Difference in per cent. units of moisture					1.1
9	1	111	24	87	78.4
	2	120	27	93	77.5
	3	135	31	104	77.0
	4	111	25	86	77.5
Difference in per cent. units of moisture					1.4
10	1	98	33	75	76.5
	2	155	34	121	78.1
	3	105	25	80	76.2
	4	122	27	95	77.9
Difference in per cent. units of moisture					1.9
Average difference in per cent. units of moisture					2.2

APPENDIX 17

Quantities of Dry Matter and Nutrients in Grass-Clover Herbage ensiled during 1953, 1954, and 1955 and of the Silages.

Crop Treatment	Fresh Matter in lb.	Fresh Matter out lb.	Diff lb.	Dry Matter in lb.	Dry Matter out lb.	Diff lb.	Crude Protein in lb.	Crude Protein out lb.	Diff lb.	Crude Fibre in lb.	Crude Fibre out lb.	Diff lb.	Ash in lb.	Ash out lb.	Diff lb.	N.F.E. in lb.	N.F.E. out lb.	Diff lb.
1953																		
Fresh	1568	1412	156	290.1	240.0	50.1	37.4	31.7	5.7	80.4	79.0	1.4	24.7	21.4	3.3	141.9	100.8	41.1
Fresh	1568	1395	173	290.1	235.8	54.3	37.4	31.6	5.8	80.4	77.8	2.6	24.7	22.2	2.5	141.9	97.1	44.8
Wilted 17½ hours	1397	1329	68	303.1	260.5	42.6	38.2	34.6	3.6	86.4	82.6	3.8	25.2	23.7	1.5	147.3	111.8	35.5
Wilted 17½ hours	1397	1359	38	303.1	266.4	36.7	38.2	36.2	2.0	86.4	86.8	+0.4	25.2	24.8	0.4	147.3	110.6	36.7
Wilted 20 hours	1377	1268	109	319.5	275.2	44.3	40.3	37.2	3.1	91.1	87.0	4.1	26.5	25.0	1.5	155.3	117.8	37.5
Wilted 20 hours	1377	1354	23	319.5	292.5	27.0	40.3	38.0	2.3	92.7	92.7	+1.6	26.5	27.8	+1.3	155.3	125.2	30.1
Wilted 22½ hours	1377	1332	45	370.4	318.3	52.1	46.7	48.1	+1.4	106.7	98.0	8.7	30.0	31.5	+1.5	179.6	131.1	48.5
Wilted 22½ hours	1377	1324	53	370.4	313.8	56.6	46.7	43.0	3.7	106.7	102.9	3.8	30.0	28.2	1.8	179.6	130.2	49.4
1954																		
Fresh)	1552	1489	63	299.5	245.7	53.8	36.8	30.2	6.6	88.4	80.1	8.3	23.4	19.9	3.5	145.0	108.1	36.9
Wilted 8 hours) Mown	1563	1484	79	389.2	387.3	1.9	42.0	46.1	+ 4.1	113.6	112.0	+8.4	28.4	31.0	+2.6	197.3	176.6	20.7
Wilted 27 hours)	1478	1451	27	418.3	361.3	57.0	43.9	44.1	+0.2	124.7	117.1	7.6	30.5	34.0	+3.5	210.8	155.4	55.4
Fresh)	1573	1356	217	286.3	234.6	51.7	34.1	28.9	5.2	80.5	74.8	5.7	27.2	27.4	+0.2	138.9	96.4	42.5
Wilted 4 hours) Bruised	1567	1470	97	318.1	339.6	+21.5	37.5	45.2	+ 7.7	93.2	104.9	+11.7	30.2	37.7	+7.5	150.8	141.6	9.2
Wilted 8 hours)	1579	1439	140	385.3	328.1	57.2	45.9	37.1	8.8	110.2	98.1	12.1	35.1	40.0	+4.9	186.5	143.1	43.4
1955																		
Fresh - no addition	1680	1426	254	342.7ø	268.1	74.6	51.7	43.4	8.3	67.5	61.4	6.1	31.2	26.8	4.4	185.4	128.4	57.0
Fresh - molasses*	1714	1521	193	354.8ø	302.7	52.1	52.2	50.2	2.0	67.1	66.9	0.2	30.9	31.2	+0.3	197.6	145.3	52.3
Fresh - metabisulphitex	1689	1554	135	366.5	312.4	54.1	54.6	55.0	+0.4	73.3	67.5	5.8	33.4	37.5	+4.1	197.9	143.1	54.8
Wilted - no addition	1604	1550	54	463.6ø	376.7	86.9	54.7	55.0	+0.3	102.9	86.3	16.6	36.6	36.9	+0.3	260.1	187.2	72.9
Wilted - molasses*	1714	1635	79	500.5ø	434.9	65.6	65.1	59.1	6.0	110.1	103.1	7.0	43.5	41.3	2.2	271.8	218.3	53.5
Wilted - metabisulphitex	1689	1624	65	537.1	462.8	74.3	63.4	67.6	+4.2	116.0	101.8	14.2	44.6	47.7	+3.1	302.4	231.9	70.5

* includes 15 lb. water, and 19 lb. molasses on fresh matter basis

ø includes 9 lb. molasses on dry matter basis

x includes 12 lb. metabisulphite on dry matter basis.

(Contd.)

APPENDIX 17 (contd)

Chemical Composition of Fresh and Wilted Grass-clover Herbage ensiled during 1953, 1954 and 1955, and of the Silages.

Crop Treatment	Moisture Content %	Dry Matter Content %	Crude Protein %	Crude Fibre %	Ash %	N-Free Extracts %
CROP - 1953						
Fresh	81.5	18.5	12.9	27.7	8.5	48.9
Fresh						
Wilted 17½ hours	78.3	21.7	12.6	28.5	8.3	48.6
Wilted 17½ hours						
Wilted 20 hours	76.8	23.2	12.6	28.5	8.3	48.6
Wilted 20 hours						
Wilted 22½ hours	73.1	26.9	12.6	28.8	8.1	48.5
Wilted 22½ hours						
SILAGES - 1953						
Fresh	83.0	17.0	13.2	32.9	8.9	42.0
Fresh	83.1	16.9	13.4	33.0	9.4	41.2
Wilted 17½ hours	80.4	19.6	13.6	32.6	9.3	41.5
Wilted 17½ hours	80.4	19.6	13.3	31.7	9.1	42.9
Wilted 20 hours	78.4	21.6	13.0	31.7	9.5	42.8
Wilted 20 hours	78.3	21.7	13.5	31.6	9.1	42.8
Wilted 22½ hours	76.1	23.9	15.1	30.8	9.9	41.2
Wilted 22½ hours	76.3	23.7	13.7	32.8	9.0	41.5
CROP - 1954						
Fresh)	80.7	19.3	12.3	29.5	7.8	48.4
Wilted 8 hours) Mown	75.1	24.9	10.8	29.2	7.3	50.7
Wilted 27 hours)	71.7	28.3	10.5	29.8	7.3	50.4
Fresh)	81.8	18.2	11.9	28.1	9.5	48.5
Wilted 4 hours) Bruised	79.7	20.3	11.8	29.3	9.5	47.4
Wilted 8 hours)	75.6	24.4	11.9	28.6	9.1	48.4
SILAGES - 1954						
Fresh)	83.5	16.5	12.3	32.6	8.1	44.0
Wilted 8 hours) Mown	73.9	26.1	11.9	31.5	8.0	45.6
Wilted 27 hours)	75.1	24.9	12.2	32.4	9.4	43.0
Fresh)	82.7	17.3	12.3	31.9	11.7	41.1
Wilted 4 hours) Bruised	76.9	23.1	13.3	30.9	11.1	41.7
Wilted 8 hours)	77.2	22.8	11.3	29.9	12.1	43.4
CROP - 1955						
Fresh - no addition	79.6	20.4	15.1	19.7	9.1	54.1
Fresh - molasses	79.3	20.7	14.7	18.9	8.7	55.7
Fresh - metabisulphite	78.3	21.7	14.9	20.0	9.1	54.0
Wilted 18½ hr. - no addition	71.1	28.9	11.8	22.2	7.9	56.1
Wilted 18½ hr. - molasses	70.8	29.2	13.0	22.0	8.7	54.3
Wilted 18½ hr. - metabisulphite	68.2	31.8	11.8	21.6	8.3	56.3
SILAGES - 1955						
Fresh - no addition	81.2	18.8	16.2	22.9	10.0	47.9
Fresh - molasses	80.1	19.9	16.6	22.1	10.3	48.0
Fresh - metabisulphate	79.9	20.1	17.6	21.6	12.0	45.8
Wilted 18½ hr. - no addition	75.7	24.3	14.6	22.9	9.8	49.7
Wilted 18½ hr. - molasses	73.4	26.6	13.6	23.7	9.5	50.2
Wilted 18½ hr. - metabisulphite	71.5	28.5	14.6	22.0	10.3	50.1

(contd.)

APPENDIX 17 (contd.)

The Quality and Losses of Fresh and Wilted Grass-clover Silage made during 1953, 1954 and 1955

(organic acids determined on the fresh matter, nutrient losses calculated on the dry matter)

Type of Silage	Quality				Losses						
	pH	Lactic %	Acetic %	Butyric %	Fresh Matter %	Dry Matter %	Corrected Dry Matter %	Crude Protein %	Crude Fibre %	Ash %	N.F.E. %
1953 SILAGES											
Fresh	4.0	1.39	0.42	-	9.9	17.3) 18.0	15.3) 16.2	15.2) 15.4	1.7) 2.5	13.4) 11.8	29.0) 30.3
Fresh	4.0	1.26	0.40	0.03		18.7)	17.1)	15.5)	3.2)	10.1)	31.6)
Wilted 17½ hours	4.0	1.19	0.25	0.01	4.9	14.1)	11.2)	9.4)	4.4)	6.0)	24.1)
Wilted 17½ hours	4.0	-	0.20	0.02	2.7	12.1)	13.3)	5.2)	+0.5)	1.6)	24.9)
Wilted 20 hours	4.3	1.30	0.17	0.02	7.9	13.9) 13.0	7.8) 12.3	7.7) 5.5	4.5) 3.1	5.7) 1.6	24.1) 24.5
Wilted 20 hours	4.3	1.12	0.17	-	1.7	8.5)	13.3)	5.7)	+1.8)	+4.9)	19.4)
Wilted 22½ hours	4.4	1.28	0.12	0.05	3.3	14.1)	13.6)	+3.0)	8.2)	+5.0)	27.0)
Wilted 22½ hours	4.3	1.22	0.14	0.02	3.8	15.3)	14.8)	7.9)	3.6)	6.0)	27.5)
1954 SILAGES											
Fresh)	3.8	1.40	0.54	0.00	4.1	18.0	16.0	17.9	9.4	15.0	25.4
Wilted 8 hours) Mown	4.4	1.11	0.29	trace	5.1	0.5	0.3	+ 9.8	+ 7.4	+ 9.2	10.5
Wilted 27 hours)	4.3	1.13	0.25	trace	1.8	13.6	12.9	+0.5	6.1	+11.5	26.3
Fresh)	3.9	1.33	0.57	0.00	13.8	18.1	15.7	15.2	7.1	+0.7	30.6
Wilted 4 hours) Bruised	3.8	1.70	0.85	0.00	6.2	+ 6.8	+10.0	+20.7	+12.6	+24.8	6.1
Wilted 8 hours)	4.0	1.74	0.60	0.00	8.9	14.8	13.0	19.2	11.0	+14.0	23.3
1955 SILAGES											
Fresh - no addition	4.1	2.56	0.32	0.00	15.1	21.8	20.5	16.1	9.0	14.1	30.7
Fresh - molasses	3.9	2.38	0.36	0.04	11.3	14.7	13.4	3.8	0.3	+1.0	26.5
Fresh - metabisulphite	4.6	1.45	0.08	1.31	8.0	14.8	13.5	+0.7	7.9	+12.3	27.7
Wilted 18½ hr. - no addition	4.0	2.22	0.26	0.03	3.4	18.7	18.1	+0.5	16.1	+ 0.8	28.0
Wilted 18½ hr. - molasses	4.1	2.12	0.24	0.03	4.6	13.1	12.4	9.2	6.4	5.1	19.7
Wilted 18½ hr. - metabisulphite	5.0	1.65	0.02	0.23	3.8	13.8	13.2	+6.6	12.2	+7.0	23.3

Effluent Data - 1953 Experiment

Date	LIQUID gal.*	LIQUID lb.	TOTAL SOLIDS g./100 ml.	TOTAL SOLIDS lb. dry matter	NITROGEN g./100 ml.	NITROGEN lb. nitrogen	TOTAL SUGAR mg./100 ml.	pH
8th June 1953	0.44	4.49	2.62	0.12	0.074	0.003	248	6.4
17th " "	4.97	50.69	6.91	3.50	0.238	0.12	202	4.4
22nd " "	0.88	8.98	6.91	0.62	0.238	0.02	147	4.3
30th " "	1.28	13.06	7.16	0.94	0.2499	0.033	132	4.6
4th March 1954	2.81	28.66	6.87	1.97	0.198	0.057		4.6
5th " "	0.19	1.94	6.09	0.12	0.198	0.004		
8th " "	0.47	4.79	6.09	0.29	0.198	0.009		
TOTALS	11.04	112.61		7.56	0	0.246		
8th June 1953	0.16	1.63	1.33	0.02	0.048	0.0008	101	6.8
17th " "	5.63	57.43	7.06	4.05	0.238	0.14	229	4.4
22nd " "	1.19	12.14	7.06	0.86	0.231	0.03	202	4.3
30th " "	1.28	13.06	7.20	0.94	0.233	0.03	124	4.7
4th March 1954	2.56	26.11	7.32	1.91	0.188	0.05	-	4.6
5th m " "	0.19	1.94	5.99	0.12	0.188	0.004	-	-
8th March 1954	0.47	4.79	5.99	0.29	0.188	0.009	-	-
TOTALS	11.48	117.10		8.19		0.2638		

* 1 gallon of silage effluent = 10.2 lb.

APPENDIX 19

Moisture contents, dry matter contents and pH values of core samples of Fresh and Wilted Silage - 1953 Experiment.

Core Replicate	Type of Silage	Moisture Content %		Dry Matter %		pH Value	
1		81.6		18.4		3.7	
2		81.8		18.2		3.7	
3	fresh	82.1	81.9	17.9	18.1	3.7	3.7
4		81.9		18.1		3.7	
5		82.2		17.8		3.7	
1		81.4		18.6		3.8	
2		82.1		17.9		3.7	
3	fresh	81.9	81.8	18.1	18.2	3.8	3.8
4		81.3		18.7		3.7	
5		82.3		17.7		3.8	
1		76.4		23.6		4.1	
2		75.8		24.2		4.2	
3	wilted $22\frac{1}{2}$ hr.	76.0	76.0	24.0	c24.0	4.2	4.2
4		76.0		24.0		4.2	
5		75.9		24.1		4.2	
1		76.1		23.9		4.4	
2		76.0		24.0		4.3	
3	wilted $22\frac{1}{2}$ hr.	75.8	75.8	24.2	24.2	4.3	c4.3
4		75.6		24.4		4.2	
5		75.5		24.5		4.3	

APPENDIX 20.

Moisture contents of Fresh and Wilted Grass-Clover Herbage Samples Collected in the Field and at the Silo - 1954 Experiment.

Crop Treatment		Fresh Matter gm.	Moisture Content %	
SAMPLES TAKEN IN THE FIELD				
Fresh	Bruised	926	80.5	81.1
Fresh	Bruised	1027	81.6	
Wilted 4 hours	Bruised	876	78.4	78.2
Wilted 4 hours	Bruised	1043	77.9	
Wilted 8 hours	Bruised	865	75.3	75.1
Wilted 8 hours	Bruised	770	74.9	
Fresh	Mown	835	80.7	81.1
Fresh	Mown	744	81.5	
Wilted 8 hours	Mown	703	74.8	75.0
Wilted 8 hours	Mown	758	75.1	
Wilted 27 hours	Mown	936	69.8	71.2
Wilted 27 hours	Mown	678	72.6	
SAMPLES TAKEN AT THE SILO				
Fresh	Bruised	1020	82.1	81.8
Fresh	Bruised	912	81.4	
Wilted 4 hours	Bruised	989	79.6	79.7
Wilted 4 hours	Bruised	929	79.8	
Wilted 8 hours	Bruised	844	73.9	
Wilted 8 hours	Bruised	953	76.7	75.6
Wilted 8 hours	Bruised	663	75.1	
Wilted 8 hours	Bruised	542	76.8	
Fresh	Mown	1025	80.9	80.7
Fresh	Mown	961	80.5	
Wilted 8 hours	Mown	954	74.9	75.1
Wilted 8 hours	Mown	722	74.4	
Wilted 8 hoursv	Mown	885	75.6	
Wilted 8 hours	Mown	817	75.4	
Wilted 27 hours	Mown	1089	71.5	
Wilted 27 hours	Mown	960	71.6	
Wilted 27 hours	Mown	850	72.0	71.7
Wilted 27 hours	Mown	987	71.9	
Wilted 27 hours	Mown	832	71.6	

APPENDIX 21

Temperature Readings Recorded during 1954 Experiment (degrees fahrenheit)

Type of Silage	Thermocouple Number	DAYS AFTER ENSILAGE																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Fresh Bruised Herbage	1	52	57	57	47	53		58	56	56	54	53	52		52	54	56	55	56
	2	52	57	56	47	53		58	55	55	54	53	52		52	56	56	54	55
	3	52	57	54	46	52		58	56	56	53	53	52		52	54	56	53	54
	4	53	57	56	46	51		58	58	57	54	53	51		51	53	55	54	54
	5	53	76	55	45	51		59	58	57	54	53	53		52	56	55	53	53
		52	61	56	46	52		58	57	56	54	53	52		52	55	56	54	54
Bruised herbage wilted 4 hours	1	57	62	61	53	57		60	57	58	57	57	54		53	57	57	57	58
	2	57	63	63	53	57		62	60	60	58	57	55		53	56	57	57	58
	3	57	62	59	53	57		59	57	58	56	56	54		53	56	57	57	57
	4	57	62	59	53	64		50	51	60	57	56	54		54	56	57	57	57
	5	57	62	60	53	58		62	61	62	58	58	56		52	56	56	57	57
		57	62	60	53	59		59	57	60	57	57	55		53	56	57	57	57
Bruised herbage wilted 8 hours	1	57	61	58	49	54		58	57	57	56	56	53		53	56	57	56	57
	2	57	61	58	49	54		62	60	58	56	56	53		53	56	57	56	57
	3	57	59	58	48	54		60	58	57	56	56	53		53	56	57	56	57
	4	58	59	58	48	54		62	61	59	58	57	53		53	56	57	56	57
	5	58	86	74	48	53		62	61	59	58	57	56		52	56	56	56	56
		57	65	61	48	54		61	59	58	56	56	54		53	56	57	56	57
Fresh long Herbage	1	55	64	61	52	55		57	55	62	58	56	55		52	55	57	57	57
	2	55	63	60	52	55		58	57	58	58	56	54		52	54	56	56	57
	3	55	63	59	52	54		57	56	77	57	55	53		57	57	57	56	57
	4	55	63	60	64	54		57	57	61	57	56			53	55	56		
	5	56	63	59	52	54		57	56	68	57	55	54		53	54	56	57	55
		55	63	60	54	54		57	56	65	57	56	54		53	55	56	56	56
Long Herbage wilted 8 hours	1	58	76	62	51	54		59	58	58	57	57	54		53	56	58	57	57
	2	58	64	62	51	54		60	59	58	57	57	54		53	55	57	57	57
	3	58	63	59	51	54		58	56	56	56	55	53		53	56	57	57	57
	4	58	64	60	51	54		58	58	57	57	56	54		53	56	57	57	56
	5	58	64	61	51	54		58	58	58	57	55	53		52	55	56	57	56
		58	66	61	51	54		59	58	57	57	56	54		53	56	57	57	57
Long Herbage wilted 27 hours	1			66	53	55		57	54	62	58	56	54		53	56	57	57	57
	2			67	57	59		62	60	59	57	57	55		53	56	57	57	57
	3			66	56	57		58	57	63	59	57	54		54	57	58	57	57
	4			66	57	58		63	61	64	61	58	57		54	57	58	57	57
	5			67	58	59		63	62	67	67	58	58		54	57	58		57
				66	56	58		60	59	63	60	57	56		54	57	58	57	57

APPENDIX 22

Effluent Data - 1954 Experiment

DATE	LIQUID Gal.**	LIQUID lb.	TOTAL SOLIDS g/100ml	TOTAL SOLIDS lb dry matter	NITROGEN g/100ml	NITROGEN lb nitrogen	TOTAL SUGAR mg/100ml	pH
EFFLUENT FROM BRUISED SILAGE								
5th June 1954	1.00	10.20	6.06	0.62	0.13	0.013	1072	4.3
11th " "	1.75	17.87	7.01	1.65	0.19	0.045	770	4.1
11th " "	0.56	5.71						
17th " "	1.31	13.36	6.53	1.08	0.21	0.035	451	4.1
17th " "	0.31	3.16						
24th " "	1.28	13.06	6.63	0.87	0.23	0.030	472	4.1
2nd July "	0.44	4.49	7.19	1.01	0.25	0.035	233	4.3
2nd July "	0.94	9.59						
9th July "	0.28	2.86	6.89	0.55	0.23	0.018	194	4.3
9th " "	0.50	5.10						
16th " "	0.53	5.41	7.34	0.46	0.25	0.016	152	4.3
16th " "	0.09	0.92						
13th January 1955	1.50	15.30	6.96	1.06	0.27	0.041	-	4.3
TOTALS	10.49	107.03		7.30		0.233		
EFFLUENT FROM LONG SILAGE								
14th June 1954 18th " " 2nd July " 15th " "	0.34	3.47	6.91	0.42	0.28	0.017	-	5.5
14th January 1955	0.25	2.55						
TOTALS	0.59	6.02		0.42		0.017		

** 1 gallon of silage effluent = 10.2 lb.

APPENDIX 23

Moisture contents, dry matter contents and pH values of core samples of Fresh and Wilted Silage - 1954 Experiment.

Core Replicate	Type of Silage	Moisture Content %		Dry Matter %		pH Value	
1	fresh bruised	82.5	81.7	17.5	18.3	3.9	3.8
2		82.0		18.0		3.8	
3		81.3		18.7		3.8	
4		81.6		18.4		3.8	
5		81.3		18.7		3.9	
1	bruised and wilted 8 hr.	75.7	75.7	24.3	24.3	3.9	c3.9
2		76.3		23.7		4.0	
3		75.6		24.4		4.0	
4		75.6		24.4		3.9	
5		75.3		24.7		3.9	
1	fresh mown	80.3	81.7	19.7	18.3	3.7	3.7
2		82.4		17.6		3.7	
3		82.1		17.9		3.8	
4		82.1		17.9		3.7	
5		81.5		18.5		3.7	
1	mown and wilted 27 hr.	73.9	74.2	26.1	25.8	4.1	4.3
2		74.2		25.8		4.5	
3		74.2		25.8		4.2	
4		74.0		26.0		4.2	
5		74.5		25.5		4.4	

APPENDIX 24

Variations in Moisture Content of Silage Cores extracted from silos containing Bruised-wilted and Mown-wilted grass-clover herbage - 1954 Experiment.

Core Number	Core Section	Location in silo	Bruised-wilted silage		Ordinary wilted silage	
			Fresh Matter gm.	Moisture Content %	Fresh Matter gm.	Moisture Content %
	1		68.3	80.4	90.7	80.0
	2	top	46.6	76.2	84.3	75.6
	3		61.8	75.2	67.9	72.2
	4		68.6	75.2	64.3	74.7
1	5	middle	65.1	72.2	65.4	71.9
	6		72.0	76.0	63.1	71.3
	7		61.3	74.6	56.4	71.6
	8		66.7	75.4	82.7	74.6
	9	bottom	77.9	76.1	88.7	74.2
	10		70.0	75.4	65.6	72.9
	1		74.5	82.1	80.8	78.2
	2	top	79.9	77.2	73.5	75.5
	3		78.6	76.3	67.7	73.3
	4		97.9	74.0	79.0	74.6
2	5	middle	81.9	76.3	61.7	73.9
	6		93.8	76.0	71.6	73.7
	7		77.9	75.6	77.1	73.7
	8		85.8	76.1	69.2	73.6
	9	bottom	99.2	75.3	60.7	73.5
	10		85.9	73.9	58.2	72.3
	1		73.6	78.3	74.0	77.2
	2	top	63.8	77.1	55.2	75.4
	3		74.2	75.3	70.5	72.6
	4		80.9	74.4	48.6	71.6
3	5	middle	87.6	75.3	56.2	75.3
	6		76.8	75.9	63.5	72.9
	7		95.4	74.8	73.2	75.3
	8		70.9	76.0	75.9	73.4
	9	bottom	70.4	73.7	73.2	75.0
	10		56.6	75.3	70.7	73.3
	1		72.5	78.2	57.4	79.1
	2	top	77.6	75.9	73.1	76.6
	3		69.4	76.1	52.5	73.5
	4		91.2	75.7	54.0	73.7
4	5	middle	84.0	76.4	71.4	72.7
	6		74.0	75.3	78.9	73,6
	7		87.6	76.1	76.7	73.9
	8		79.0	75.3	75.1	71.2
	9	bottom	62.8	73.9	85.3	74.0
	10		56.1	72.7	80.1	71.9
	1		80.3	78.0	78.4	80.4
	2	top	72.3	76.9	61.4	75.1
	3		83.4	75.9	62.5	73.9
	4		66.0	75.2	66.7	72.7
5	5	middle	86.5	75.7	60.6	74.3
	6		80.7	76.5	64.2	75.4
	7		81.0	74.9	69.8	72.9
	8		80.3	73.3	66.5	74.9
	9	bottom	81.0	74.0	54.5	73.0
	10		78.3	72.2	54.9	72.9

APPENDIX 25

Temperature Readings Recorded during 1955 Experiment (degrees fahrenheit)

Type of Silage	Thermocouple Number	DAYS AFTER ENSILAGE																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Fresh (No additive)	1	64	69	68	66		67	65	58	50	61	58		54	55		57	58	55
	2	64	69	67	67		68	66	61	54	63	62		57	56		57	57	55
	3	63	68	66	65		68	66	61	56	63	62		57	56		56	57	54
	4	63	67	65	64		67	65	60	56	62	60		55	55		56	57	54
	5	63	67	65	66		68	67	62	57	65	63		58	56		57	57	54
		63	68	66	66		68	66	60	55	63	61		56	56		57	57	54
Fresh (Molasses)	1	63	63	58	62		57	59	53	52	52	53		52	50		56	57	53
	2	68	71	69	69		71	67	63	57	62	60		54	53		56	57	54
	3	72	75	74	73		74	69	65	60	64	62		57	56		57	57	54
	4	69	73	71	70		71	63	63	57	61	59		54	53		55	57	54
	5	72	74	71	70		72	63	63	57	62	59		54	53		56	57	54
		69	71	69	69		69	64	61	57	60	59		54	53		56	57	54
Fresh (Metabisulphite)	1	82	88	84	81		80	72	66	61	67	64		58	57		57	57	56
	2	86	90	87	83		83	73	67	62	67	65		59	57		58	57	55
	3	88	91	88	84		83	73	68	62	67	64		58	57		57	57	54
	4	83	89	82	76		76	68	64	57	63	61		56	56		57	57	55
	5	87	91	88	87		86	76	69	64	68	67		60	58		58	57	55
		85	90	86	82		82	72	67	61	66	64		58	57		57	57	55
Wilted (No additive)	1	53	52	57	59		60	58	53	62	62	58		58	58		59	57	56
	2	63	63	54	58		58	60	55	62	63	58		58	59		59	57	56
	3	63	55	63	65		63	61	57	62	63	57		57	58		59	57	56
	4	63	64	57	60		62	61	58	65	64	59		59	61		60	57	56
	5	53	53	62	64		62	61	57	62	61	56		57	59		60	57	56
		59	57	59	61		61	60	56	63	63	58		58	59		59	57	56
Wilted (Molasses)	1	71	68	66	68		66	61	57	63	61	57		57	58		59	57	58
	2	71	68	67	69		66	62	57	63	63	58		58	58		59	57	58
	3	61	60	60	63		62	58	53	58	58	54		55	57		59	57	58
	4	58	58	58	62		62	58	56	63	63	57		58	58		60	57	58
	5	58	59	59	63		63	59	57	64	64	59		59	61		60	57	58
		64	63	62	65		64	60	56	62	62	57		57	58		59	57	58
Wilted (Metabisulphite)	1	67	67	64	67		64	60	57	59	60	56		56	57		59	56	55
	2	68	73	76	78		68	64	61	64	62	57		56	57		59	56	55
	3	68	72	74	76		67	63	57	62	61	55		54	57		58	56	55
	4	68	68	69	72		67	63	59	64	63	58		57	57		59	55	55
	5	69	69	68	72		68	65	62	67	66	60		58	56		59	56	55
		68	70	70	73		67	63	59	63	62	57		56	57		59	56	55

APPENDIX 26

Effluent Data - 1955 Experiment

DATE	LIQUID		TOTAL SOLIDS		NITROGEN		
	Gal.**	lb.	g/100ml	lb dry matter	g/100ml	lb nitrogen	pH
FRESH UNTREATED SILAGE							
2nd June 1955	3.22	32.84	8.6	2.82	0.22	0.072	5.9
6th " "	1.66	16.93	10.1	1.71	0.29	0.049	4.5
9th " "	0.91	9.28	10.3	0.96	0.32	0.030	4.7
13th " "	0.66	6.73	10.7	0.72	0.33	0.022	4.5
16th " "	0.34	3.47	11.2	0.39	0.35	0.012	4.6
20th " "	0.53	5.41	10.8	0.58	0.37	0.020	4.4
23rd " "	0.38	3.88	10.5	0.41	0.41	0.016	4.4
28th " "	0.38	3.88	10.8	0.42	0.38	0.015	4.6
30th " "	0.19	1.94	9.6	0.19	0.38	0.007	4.6
9th January 1956	3.00ø	30.60	10.3	0.32	0.42	0.129	3.9
TOTALS	11.27	114.96		8.52		0.372	
FRESH MOLASSED SILAGE							
2nd June 1955	4.56	46.51	15.9	7.40	0.22	0.102	4.6
6th " "	1.19	12.14	11.3	1.37	0.32	0.039	4.4
9th " "	0.56	5.71	11.2	0.64	0.34	0.019	4.5
13th " "	0.53	5.41	10.8	0.58	0.34	0.018	4.4
16th " "	0.28	2.86	10.8	0.31	0.36	0.010	4.6
20th " "	0.28	2.86	11.2	0.32	0.39	0.011	4.4
23rd " "	0.25	2.55	10.9	0.28	0.39	0.001	4.5
28th " "	0.50	5.10	11.4	0.58	0.40	0.020	4.5
30th " "	0.19	1.94	10.0	0.19	0.40	0.008	4.5
9th January 1956	3.00ø	30.60	10.5	0.32	0.42	0.129	4.2
TOTALS	11.34	115.68		11.99		0.357	
FRESH METABISULPHITE SILAGE							
2nd June 1955	1.22	12.44	10.7	1.33	0.21	0.026	5.9
6th " "	0.31	3.16	12.6	0.40	0.31	0.010	5.9
9th " "	0.16	1.63	13.8	0.22	0.34	0.006	6.0
9th January 1956	3.30	33.70	10.5	0.35	0.45	0.152	4.6
TOTALS	4.99	50.93		2.30		0.042	

** 1 gallon of silage effluent = 10.2 lb.

ø estimated.

APPENDIX 27

Meteorological data obtained during the filling of four trench silos with wilted grass-clover herbage - 1955 Farm Experiment.

Date	Time of Day	Wet bulb °F	Dry bulb °F	Relative Humidity %	Saturation Deficit mm/Hg	Precipitation in 24 hours m.m.	Daily Sunshine hr.
			S I L O 1				
13th June	10 a.m.	49	53	75	2.6		
" "	12 noon	51	58	61	4.5	4.2	8.5
" "	4 p.m.	51	63	42	8.0		
14th June	10 a.m.	57	60	83	2.2		
" "	12 noon	57	59	89	1.4		1.2
" "	3 p.m.	58	62	79	3.0		
15th June	10 a.m.	50	56	65	3.8		
" "	12 noon	52	58	66	4.0	-	12.9
" "	3 p.m.	54	63	55	6.1		
16th June	10 a.m.	48	51	81	1.8		
" "	12 noon	49	52	81	1.8	-	0
" "	3 p.m.	49	53	75	2.5		
17th June	10 a.m.	49	55	65	3.7		
" "	12 noon	50	57	61	4.2	-	13.5
" "	3 p.m.	54	61	63	4.8		
			S I L O 2				
16th June	10 a.m.	48	51	81	1.8		
" "	12 noon	49	52	81	1.8	-	0
" "	3 p.m.	49	53	75	2.5		
17th June	10 a.m.	49	55	65	3.6		
" "	12 noon	50	57	61	4.1	-	13.5
" "	3 p.m.	54	61	63	4.7		
" "	12 noon	52	59	62	4.5	0.1	5.4
" "	3 p.m.	55	64	56	6.1		
5th July	10 a.m.	56	59	83	2.1		
" "	12 noon	58	62	79	3.0	-	10.6
" "	3 p.m.	57	61	78	3.0		
6th July	10 a.m.	54	58	77	2.8		
" "	12 noon	60	66	71	4.5	-	8.8
" "	3 p.m.	-	-	-			
7th July	10 a.m.						
" "	12 noon	64	72	65	6.3	-	2.3
" "	3 p.m.	64	74	58	8.2		
8th July	10 a.m.	64	69	76	4.3		
" "	12 noon	64	71	68	5.8	-	10.4
" "	3 p.m.	65	74	61	6.9		
9th July	10 a.m.	54	55	94	0.7		
" "	12 noon	58	60	89	1.5	-	9.8
" "	3 p.m.	-	-				
10th July							
" "	No ensilage on this day					-	7.5
" "							
11th July	10 a.m.	58	60	89	1.5		
" "	12 noon	61	66	75	4.0	-	11.1
" "	3 p.m.	58	60	89	1.4		