Onderstepoort Journal of Veterinary Science and Animal Industry, Volume 22, Number 2, April, 1949.

Printed in the Union of South Africa by the Government Printer, Pretoria.

The Carbohydrate Content of Lucerne under Different Meteorological and Physiological Conditions.

By MARGUERITE HENRICI, Ph.D., D.Sc., Senior Professional Officer Veld Reserve, Fauresmith; Division of Botany and Plant Pathology.

The present investigation deals with the contents of starch, sucrose and reducing sugars in two varieties of lucerne, Hunters River and Provence. In some instances reducing sugars were further divided into fructose and glucose. In other cases the fibre content was ascertained as well to see whether there was any relationship between a high starch and a low fibre content and vice versa. The investigation does not intend to give the seasonal trend of the changes in the carbohydrate content of the lucerne: single phases characterised by rapid meteorological changes or physiological variations were picked out to see whether these phases had any influence on the contents of the direct assimilates. Such phases were changes from winter to spring, frosting of the lucerne on autumn mornings, excessive heat causing wilting, temporary wilting, permanent wilting, damage by insects and damage caused by trampling animals.

The lucerne was grown in plots on the Veld Reserve, Fauresmith; it could be easily watered wholly or partly as it was required for wilting experiments. Some lucerne in pots was also used. The collecting began in 1941 when definite agricultural stages were sampled. Later physiological samples were taken covering 24 to 30 hours during which time four to five samples were taken early in the morning, at noon, late in the afternoon, at midnight and again early in the morning. Some sampling started at 12 a.m. and therefore the last sample was again taken at 12 a.m. the following day. In some cases when cut lucerne was allowed to wilt, samples in the day-time were taken every *two* to *three* hours. When progressive wilting was under observation, the samples were taken once a day during a couple of weeks.

The plants were cut with sickles, about ½ in. above the ground, and thrown into 90 per cent. alcohol immediately to kill enzymatic action. Owing to the water of the plant the percentage of the alcohol naturally dropped considerably. The plants were then removed from the alcohol, dried, separated into stems, flowers and leaves and ground to a fine powder with a hammer mill.

One can hardly mention the determination of starch and sugars and fibre collectively, as special analyses are involved for the former, and the latter is the ordinary feeding stuff analysis. The information obtained from the fibre should just serve as a basis for a more detailed study to be done in the near future.

Received for publication on 27th November, 1945.—Editor.

The method used for the starch determination is described in the Methods of Analysis (1926, p. 119) except that instead of malt extract an excellent Merck preparation of diastase was used, 0·1 gram being sufficient for 15 per cent of starch; the diastase contained 23·7 per cent. reducing sugars. The final reducing sugar resulting from the starch was determined with Bertrand's solution (Klein 1932, p. 783, ff) and Klein's tables were used for calculation.

The sucrose and reducing sugars were extracted as described in Methods of Analysis (p. 118). After the evaporation of the alcohol, however, the solution, made up to a definite volume, was treated with invertase for the determination of sucrose and reducing sugars, the titration being done by Bertrand's solution. The invertase was prepared according to Klein's prescription (1932, p. 838). It was found in preliminary experiments that acid hydrolysis instead of treatment with invertase gave results 300 per cent. and more too high. The time for the invertase to act was two hours at 38° C.

For the reducing sugars the hypoiodate method of Van der Planck was used (1937). Later when it became obvious that glucose varied very little in amount and was only present in small quantities, the reducing sugars were no longer separated.

The proportion of stems to leaves and flowers was determined to ascertain the absolute amount of sugars. All values are calculated on dry matter.

The alcohol which was used for killing the plants, was tested after the material was taken out. It did not show reducing properties.

At the start of the investigation, the clearing of the solution—e.g. the removal of reducing substances other than sugars—was tried with normal lead acetate, basic and dibasic lead acetate. Later anchor yeast was used. On the whole the clearing with baker's yeast gave the most concordant, and the smallest values.

Fresh anchor yeast was finally used for liberating the extracts from reducing substances other than sugars. The anchor yeast cakes were washed thoroughly and the filtrate thrown away; the yeast in the fresh state, after washing with water did not contain any reducing substances. One cake after drying gives about 10 gm. of yeast. The yeast after washing is dried to the crumbling stage in a desiccator and can be kept dry for a couple of days in a refrigerator. For use a 10 per cent. suspension is made and 10 volume per cent. put into the extract to be cleared. The extract is kept in the refrigerator for at least an hour and then filtered. The filtering through Whatman 40 or 41 is fairly quick, but does not give a colourless solution. A 20 per cent. suspension gives a solution which is coloured lighter, but filters exceedingly slowly. The reducing power of the solution is the same as with a 10 per cent. suspension, therefore the 10 per cent. suspension was used in subsequent experiments.

For calculations the tables in Klein (1932) or Van der Planck (1937) were used. The sugar solution treated with invertase gives the total sugars (sucrose plus reducing sugar) and the reducing sugars (the figure obtained with Van der Planck's method) has to be deducted to obtain the sucrose content.

A special sample of leaves and stem was taken at the time when the collecting took place to ascertain the water content. The sample was immediately placed into a weighing bottle and the fresh weight ascertained.

It was then dried at 104° C. for 24 hours, weighed again and the loss considered as water. The water content in the tables is expressed as percentage of the fresh matter. All values of sugar and starch are calculated on 1 gram oven-dried matter, as the material, killed in alcohol, was dried and powdered afterwards. It means that a small amount of dry matter soluble in alcohol, e.g. chlorophyll and respiration of pigments, is lost at the start. This amount is exceedingly small, as apparantly the plant as a whole, without being broken up, does not allow much diffusion, yet the alcohol was dark coloured. To save expense the alcohol was re-distilled and it was noticed that the residue was very small, the redistillation being chiefly to concentrate it, as it had taken up practically all the water of the lucerne.

In the course of the investigation the words " fresh ", " temporarily wilted " and " permanently wilted ", are used to describe the state of the plant. Plants are temporarily wilted which droop during the hot part of the day and recover through the cooler part or at least during the night. The permanently wilted lucerne does not recover during the night, and if no rain falls the conditions of wilting progress. It may of course happen that although no rain falls, the atmospheric conditions on the second day are not quite as severe as on the first, and transpiration may consequently be less, resulting in a slightly higher water content on the second day. But on the whole this is the exception and not the rule.

Meteorological conditions were recorded during all experiments, at the start taken at the meteorological screen which stood in a neighbouring plot. Later a thermohydrograph was put into the lucerne plot itself, 6 feet above the ground.

Values of Sugar and Starch Under Normal Conditions.

Table 1. *Graphs* 1 *and* 2.

It was pointed out in the introduction that it was not the intention of this investigation to demonstrate the seasonal variations of the assimilates of lucerne in the different organs. Yet from the data obtained it is obvious that variations exist, particularly for the starch content. Even under the best meteorological conditions one cannot obtain the same starch values at any time of the year, although there is no seasonal trend for high values. High starch values may occur at any time between October and April. At the utmost it can be said that in the season 1943/44 there are less high values than in the two previous and in the following seasons; the fact is of some interest as 1943/44 was one of the wettest seasons experienced in the Free State for 60 years, and the lucerne looked beautiful. A relationship between temperature and amount of starch could not be found. It must be the general meteorological conditions which lead to a quick growth and less starch formation. The highest value observed is 7·75 per cent., found in December in leaves of Provence lucerne. Provence lucerne seems to have a tendency to have a somewhat higher starch value than Hunters River. Stems have decidedly less starch than leaves, but flowers are at times very rich in starch; in March, 1943, they also reached 7 per cent.

If the daily march of the assimilates is considered, there is nothing exceptional in the trend of the starch. It could be the curve of any fodder plant with a maximum in the afternoon or evening. One noteworthy point certainly is that all starch is not dissolved in the night, and more starch is dissolved early in the morning than from dark to midnight. The plant begins to assimilate in the morning whilst there is still starch present. If it is asked whether there were periods with a lower or higher starch content than usual, it could be said that in the very rainy season 1943/44 the starch content of Provence lucerne was decidedly lower than usual (samples 2572-79; 2762-75). The sucrose content was exceptionally high in 3 early samples (2322, 2323, 2333) of Hunters River and Provence lucerne in a sundried agricultural sample which was not thrown into alcohol immediately upon cutting. Some of the agricultural samples in which stems and leaves were not separated, were sundried and only then killed with alcohol to see the effect of drying, as in a couple of instances even dried lucerne caused bloating. These experiments should be carefully compared with those in Table 7 of cut lucerne allowed to wilt. In all other samples and daily curves of fresh lucerne, the sucrose is seldom over 1·5 per cent., and if so, only in stems, not in leaves. It may often be very low or nil in stems or leaves. Total sugars in fresh lucerne is generally not more than 2 per cent, seldom 2·5 per cent. On the whole sugars during 24 hours do not show a fluctuation as large as the starch. No definite rule can be stated whether stems or leaves have higher values for reducing sugars. The highest values encountered are in the flowers. The maximum of the reducing sugars is decidedly in the day time, either early in the morning or at noon. In all early experiments not only with lucerne but with other fodder plants (to be published) the reducing sugars were divided up in fructose and glucose. It appears, however, that glucose in most of the investigated plants was only present in very small quantities and practically did not change during the 24 hours. (Compare also Archbald and Mukerjee, 1942.) Thus in further samples the glucose was not separated from the fructose and only the value for reducing sugars given. It is further evident that the amount for total sugars shows very little fluctuation in day-time. This supports Kohler's (1944) idea that in assimilation the sum of sucrose and monosaccharides is nearly constant, but not the amount of the single constituents. Kohler also expressed the view that mono- and disaccharides are formed concurrently during assimilation, and there was no proof whatsoever that monosaccharides were the precursors of the sucrose; on the contrary, sucrose and starch are the primary carbohydrates in the photosynthetic process.

It is equally evident from Table 1 that season or temperature plays a much smaller rôle in determining the amount of starch present in the leaves, than the water content of the plants. The water content of the plants again depends on the soil-water content and the relative moisture. With both these factors or one being low, the starch content of the leaves decreases.

Values and Daily Curves of Assimilates Under the Influence of Wilting.

Tables: 2, 3, 4, 7, 9. *Graphs*: 3, 4, 5, 6, 7, 8.

As has been pointed out wilting is not a well-defined process, but progressive from slight drooping to a complete drying out. Although the water content was daily determined 4 to 5 times, no definite figure at which wilting occurs, can be given, the more so as the water content itself alters during 24 hours. Normally it is higher at night than at noon, but wind and temperature influence it too, thus the maximum can as well be in the morning. What can be said is that above a certain water content (over 75 per cent.) the plants look fresh; between 66 and 75 per cent. temporary wilt occurs, and below this permanent wilt sets in. Temporarily wilted lucerne which is allowed to recover, can have a water content up to 80 per cent. One must not forget that even if the lucerne looked fresh on hot days, it was possible that leaves lost constitutional water. Thus analyses 2762-75 of Table 1 show about the same water content as the analyses in Table 2.

Wilting disturbs the usual daily curves of assimilates. According to Table 2, simple drooping even postpones or advances the time of the starch maximum (2612-2619). By drooping, the starch content of the leaves is decreased, but the stem contains more starch than in fresh lucerne. It appears that when the leaves are not turgescent, the stem acts as an assimilation organ, similar to what Déhérain and Dupont (1901) described for corn. According to Table 2 the time of the starch maximum in the leaves, is no longer at noon or evening, but may be at midnight or early in the morning, quite independently of the light and *not* in a simple relation to the water content. The actual percentage of the starch content in the leaves is or is not much affected by a first drooping (Table 2). There seems to be a tendency towards increased sugars, especially sucrose in the stems.

Table 3 in which data are compiled on the effect of repeated temporary wilting and subsequent recovery confirms the resnlts of Table 2, (*a*) the stem being an assimilation organ after the leaves show signs of wilting, (*b*) the decreasing content of starch and increasing content of sucrose. It also contains evidence that during wilting the proportion of glucose to fructose is altered, more glucose than usual being present. In spite of the high water content after recovery little starch is present (2421). Apparently repeated temporary wilting does not allow complete recovery, but gives similar values as stronger wilting.

In Table 4 the results of permanent wilt, without recovery during the night, are tabulated. In leaves and stems, but particularly in the leaves, the starch content has decreased considerably, and for both organs the maximum for starch is either early in the morning or in the night. Some very high sucrose values are encountered (2324 and 3014/21) but they do not last long, and are absent in all later values of long lasting experiments. In the leaves, moreover, there is a decrease of sucrose and a decided increase of the reducing sugars, the total amount of sugars being not very much higher than in earlier experiments but the ratio of the components is changed. It is obvious from this that there is rather a non-formation of starch, and not a dissolution of existing starch, or if there is dissolution, the sugars present do not correspond to the amount of starch which has disappeared, as the percentage of starch plus total sugars is much lower than in the experiments on temporary wilting.

The water content is much lower than in all experiments previously discussed. No definite rule, however, can be given that the lowest water content corresponds to the lowest starch content. For the human eye it is difficult to see a difference in the plant's appearance with a water content of 41 or 55 per cent. Again it has to be emphasised that no nil values of starch were recorded, although at times (2607 and 2609) the percentage was very low.

Tests on progressive wilting during a couple of weeks are tabulated in Table 9. The samples were taken between 12 noon and 2 p.m., as it was impossible to collect every few hours for any length of time. The first days correspond in their results with the ordinary wilting experiments as there is little starch and plenty of sugars present. In the experiment from 28th September 1944 to 16th October, 1944, after the fourth day, the assimilation of the leaves is only about 50 per cent. of the initial value, the stems, however, having only decreased their activity by 12 per cent. Starch especially has decreased in the stem. In the third period from the 10th to the 19th there is, especially towards the end, a renewed increase in starch and sucrose content of the leaves, although the total sugar content remains constant. For the stem the starch content and total sugar content on the average do not change between the 4th and the 19th day, but sucrose increases and reducing sugars decrease in the 3rd period. Other experiments give a similar result.

It is needless to say that with our present knowledge of metabolism the fact can hardly be explained other than as " a last kick before death ". A similar phenomenon appears when cut lucerne is allowed to dry and die in the sun (Table 7). Just before death once more an increase in starch and sucrose occurs. In the present instance the water content dropped from 72 to 44 per cent., with the sun-dried lucerne 7 per cent. The possibility of other polysaccharides being mobilized before death is not excluded. Yet it seems peculiar that sucrose and starch, and carbohydrates determined by a specific enzyme, are on the increase and not as a rule reducing sugars. Reducing matter as such is of course out of the question, as it is precipitated during the analysis.

Progressive wilting in the course of a short space of time can be observed in experiments 2744/2761 and 3057/3096 in Table 7. These experiments were really done to study prohibited migration on cut lucerne which is allowed to wilt in the sun without water, and this subject will be discussed later. For the time being only the changed ratios of the carbohydrates caused by the quick wilting and drying out will be considered. The experiment 2744/61 started with a low starch content of the leaves; the starch decreased during the day time, during the night it increased a bit, but got a final increase just before death on the 2nd day. The total sugar content of the leaves was never high. Perhaps in the period of 4 hours the changes were too rapid to be observed. There was after 8 hours a 300 per cent. increase of the total sugar in the stems, the increase being mostly sucrose. After the 11th hour the reducing sugars increased in the stems and sucrose disappeared till a final increase at death.

The experiment 3057/3096 showed the single phases of the wilting better: viz. the quick disappearance of starch in the leaves followed by a rapid increase of sucrose after the 5th hour: the continuation of the decrease of starch during the day and night with the final increase before death; the stem taking over the assimilatory function for quite a while, when the starch decreases, sucrose and reducing sugars increase. Apparently the phases are more congested, as in ordinary wilting of uncut plants! Thus the 2 sugar phases cannot be separated in rapid wilting.

Assimilates under the Influence of Prohibited Migration in Fresh and Wilted Lucerne.

Table 7. Graphs 7, 8, 9 and 10.

The experiments of Table 7 have to be compared with those of fresh uncut lucerne in Table 1, as well as amongst themselves. Thus Nos. 2277/89 have to be compared with 2762/75 (Table 1); 2744/61 to 2776/89; 3055/3106 to 3057/3097, 3051/3100, Table 1 to 3053/3102 in Table 4.

The main point to be discussed here is the prohibited migration. If uncut fresh lucerne is compared (Exp. 22.3.44-23.3.44) to cut fresh lucerne supplied with water, the following differences are registered: (*a*) the much lower starch content of the cut lucerne; on the second day practically no starch is formed. The total sugar content of the leaves is not very different, yet in the cut lucerne it consists mostly of reducing sugar, in the place of sucrose. A minimum of reducing sugars in both cases is found at 8 p.m. The water content is slightly lower in the standing lucerne. The time of the starch maximum in the uncut lucerne is spread over several hours, between 1 and 4 p.m. A sharp maximum point is found in the cut lucerne at 8 p.m.

The curve for the starch in the stem is very similar on the first day, but during the night a renewed maximum occurs in the cut lucerne. After midnight however, some starch seems to dissolve again and its products may even be leached by the water in which the stems dip. The total sugar content on the first day is decidedly higher in the cut lucerne, mostly due to fructose. The second day sugars seem to be leached out into the water.

The comparison of wilted cut to fresh cut lucerne (Exp. 21-23.3.44) reveals the following: a completely disturbed curve (Graphs 9 and 10) for the starch in the leaves which is, moreover, very low, except just before death, at a water content of 12 per cent. In the leaves of the wilted cut lucerne the sugar content is never very high, reducing sugars always predominating. Once, after 8 hours of wilting, there was a maximum of both sugars, but this did not go far above 2 per cent. In the stems of the wilted cut lucerne the starch content is considerably lower than in the fresh cut lucerne. The total sugar content is high, at first due to a high percentage of sucrose. Later the sucrose decreases, and the reducing sugars predominate. At the time of death the latter are still at a fairly high percentage.

Graphs 7 and 8 refer to excellent lucerne previous to cutting. At 6 a.m. the leaves had already nearly 7 per cent. of starch (8), when left without water, however, it immediately dropped to less than half, had a small peak at 4 p.m. after the water content had decreased very quickly from 50 to 10 per cent. Apart from a small dent the starch curve of the lucerne supplied with water, was normal, and showed only disturbances the second day at noon. The sugar content is quite normal in the plant supplied with water. In the leaves left without water, the sugars, especially the sucrose, are increased and only drop at death. The largest changes, however, occur in the stems. In the plants supplied with water, a very irregular curve appears, the single values being pretty high except before death when sugar increases. In the drying plant the percentage of starch beginning with a high value, drops after 6 hours and is irregular afterwards with a maximum before death. The total sugar content in the turgescent plant is not abnormal, except at noon on the second day. In the wilting plant, however, it is very high, mostly due to an accumulation of sucrose. It only decreases at death.

It is obvious from the above description that the first day the carbohydrate content of cut lucerne supplied with water, does not vary much from uncut lucerne; it is likely that the water leaches out some of the soluble carbohydrates and that migration is merely replaced by leaching The water in which the stems were dipped, was actually fermenting on the second day. Real prohibition of translocation only took place in the cut lucerne which was allowed to dry in the sun. There an accumulation of sugars took place similar to that in the agricultural samples. This lucerne may prove dangerous to stock especially if it comes from a good quality where masses of starch are dissolved within a few hours. The katabolism goes on very rapidly. Sugar and starch are in higher percentage in the wilted cut lucerne than in the wilted standing lucerne, but the cut lucerne offers a rather irregular curve. The peculiar point certainly is that the wilted standing lucerne has less starch than the cut lucerne.

Agricultural Samples and Grazed Lucerne.

Table 6.

It is known that "sweated" lucerne (lucerne which has been tightly packed whilst wet) often causes bloating. On the other hand, lucerne which has been cut, watered again and allowed to grow, and is then grazed, is also reported to be dangerous; hence such samples were collected for analyses (Table 6). The samples grown on the Reserve show some definite features, but nothing to warrant bloating. Actually the lucerne of Nos. 2738-2743 was grazed and heavily trampled, but the sheep did not show any ill effects. Samples of sun-dried or slightly sweated lucerne showed a very small content of sucrose, and over 1 per cent. of reducing sugar and mostly a high starch content. Sweated lucerne, which exuded a bad smell, had however, a low starch content and little reducing sugar; in the leaves more sucrose was found.

Trampled lucerne on the whole has a low starch content, perhaps because the trampling and wounding of the plants prohibit stronger photosynthetic activity; the water content as such is certainly not to blame for the shortage. The total sugar content is equally low, and the small percentage of sucrose again gives the impression of inhibited assimilation (2738-2743).

One bale of lucerne hay coming from Upington which caused bloating in oxen on the Veld Reserve, Fauresmith, was analysed. It contained a lot of total and reducing sugars, but very little sucrose. Starch was practically absent.

Damaged Lucerne.

Table 5.

Evidence on the effect of damage by insects (caterpillars) is given in Table 5. During the period of the invasion of insects, the assimilation was very limited. The starch present disappeared to a large extent in the daytime and still more during the night. New starch was only formed when the insects left. The sugars were very low as well, especially the sucrose. Contrary to ordinary wilting, the stems were more affected than the leaves.

Sheep were allowed to graze on the damaged lucerne; but they ate very little and nothing happened. No sugar accumulation took place in any case.

Starch and Fibre Content.

The question arises whether there is any correlation between the content of starch and that of fibre, in the same way as that with low starch content there would be a high fibre content and vice versa. One determination of fibre in leaves and stems was made in experiments lasting 30 hours; for experiments of long duration at suitable intervals. Going through all the tables it can be stated that the variations of the fibre content in stems are much larger (from 19-44·5 per cent.), than that for leaves (from 13·0-21·0 per cent.). Furthermore, high fibre content of leaves does not necessarily coincide with high fibre content of stems. Thus it is advisable to discuss the relation between fibre and starch for leaves and stems separately. For the leaves the following can be said: The lowest fibre content corresponds to the highest content of sugar and starch. In pots, generally, lower fibre contents are realised than in plots, evidently because the pot lucerne is more petted. The highest fibre content corresponds to the lowest content of sugar and starch. Even if this principle is clear, it does not mean that between the two extremes of fibre values there is a straight line for the corresponding starch value. A plant with 17 per cent. fibre may not always have the same starch value. It has been pointed out that there was no intention of getting the seasonal curve of assimilates as the lucerne was cut when ready for the particular experiment. Thus it is of interest to note that low fibre values could be obtained at any time of the year, particularly in pots and they were not influenced by the season, but by the treatment. The same holds good for the high fibre content.

It is of particular interest to note that temporary drooping in the leaves is not connected with a very high fibre content; the fibre is ± 18 per cent., the starch content may be still high or already decreasing and the sugar content low. In permanent wilt or progressive wilting the fibre content of the leaves, however, is high, connected with a low starch content.

For the fresh stems it is equally true that the very low fibre content is connected with the highest starch value. But there is no evidence that a high fibre content is connected with a low starch content. Temporary and permanent wilt occurs in lucerne with a low fibre content in stems and is then connected with a low starch and a high sugar content.

Ratio of Leaves to Stems.

When lucerne is fed to the animal, the ratio of leaves to stem influences the amount and the quality of the carbohydrates of the food to a large extent. Young lucerne, when the amount of leaves is taken as a whole, has a low ratio, old lucerne a high ratio; that means that plenty of leaves are present in young lucerne and plenty of stems in old lucerne. It has been shown in the previous tables that the content of sugar and starch is very different in leaves and stems. How much sugar and starch is actually present, is only revealed by the ratio. Thus this figure is given in all later experiments. The ratio varies between 0·34 and 3·5. From the tables it appears that lucerne wilts easier when it has a low ratio of leaves to stems. In a progressive wilting experiment the ratio varied for weeks only between 0·92 and 1·0. The lucerne damaged by insects had a very high ratio. Apparently the leaves were more damaged than the stems. Ordinary grazed lucerne also has a rather high ratio.

There does not seem any direct relation between the amount of starch and sugars and the ratio. Yet if a high ratio is connected with wilting, a high sugar percentage is present in the food, as sugars are generally high in the stems during wilting. This, however, is not the rule under the climatic conditions of Fauresmith, but rather the exception. There seems to be little danger of a too high sugar content of the food with a low ratio combined with wilting.

EFFECT OF FROST ON THE CARBOHYDRATE CONTENT OF LUCERNE.

Table 8. Graphs 11 and 12.

All samples collected after frost show some common features. Yet in 1944 there were large differences between samples collected at the time of early and those collected at the time of late frosts. All lucerne samples collected after frost had a high content of sugar, especially in the stems. The contrast between samples collected after early and late frosts in 1944 is that in the first instance there is little starch, but in the latter the starch content is equally high.

The experiments done at the time of early frosts will be considered first. They agree with experiences in literature (Lidforss, 1907; Voigtländer, 1909) inasmuch as plenty of sugars are present and little starch. The idea of the older literature is that starch is only formed above a certain temperature; in Europe the temperature is 6° C. In the first instance sugars are formed in place of starch by sheer physical condition, but in the second because they increase the osmotic forces of the cell and thus prevent, to a large extent, freezing and bursting of the tissue when the temperature falls below zero. The explanation is quite adequate for the plants of middle Europe or the high Alps where, combined with low temperatures in summer preventing starch formation, there are no high temperatures within the same 24 hours, favouring the formation of starch. In the Alps the light intensity may be very high after a night's frost, but even so the temperature of the thin-leaved plant is not high. In South Africa after a night with frost the temperature the next day, quite apart from the radiation, is high enough to allow starch formation unless the enzymes were damaged. Thus the presence of starch is quite feasible. The starch disappears entirely during the night especially between midnight and early morning, but in the daytime, at noon or in the afternoon, some is formed: at the same time the total sugar in the stems is very high, and at midday also in the leaves. In the stems sucrose is plentiful. It seems that in the frosted lucerne too, the stems take over the function of photosynthesis. Qualitatively the explanation seems all right. But if it is considered quantitatively, it appears that the total amount of starch plus sugars in the frosted lucerne has a tendency to be higher than in normal summer lucerne. This fact is, however, much more pronounced in the determination done after late frosts with plants in pots under excellent conditions. These plants have still an exceedingly high percentage of starch.

Logically it cannot be accepted that the assimilation after frost is so much higher than under ideal conditions in spring or summer. Thus the question arises whether all these carbohydrates are products of photosynthetic activities or whether they have their origin by some other katabolic process. It seems possible that material is transported from the root or rootneck to the stems and leaves. As in 1944 the roots of the lucerne were not analysed, nothing definite could be said, but in the winter of 1945, further analyses were done with frosted lucerne, including also the roots. These contained very high amounts of starch. During the experiment large amounts of this starch were mobilised, and sugars in the aerial parts increased for a short time to more than three times their original value. In one experiment (14-15/5/45) the starch content of the root decreased 5 per cent. within 24 hours, whilst the sugar content in the aerial parts increased 7 per cent. in the same period. Eight hours later the starch content of the root as well as the sugar content of the leaves were about normal. In the stems there was still a surplus of sugars.

If the graphs of different days with frost are compared it is found that they have not many common features. The times for all maxima are completely altered as compared with the standard Graph 1. There seems to be no definite rule whether sucrose or reducing sugars predominate in the aerial parts after frost, but on the same date it is the same sugar in stems and leaves. Apart from the very sharp peak of total sugars, either on the first or second day the trend of the sugars is very regular in the aerial parts. The starch in leaves and stems has a maximum at midnight. Contrary to these graphs, those of the roots particularly for the starch are very irregular although there is certainly a tendency to get to the same starch level as before the frost in the course of time (generally it takes longer than 24 hours!) The general impression is gained that either the starch or the sugar content is disturbed and therefore irregular, but not both at the same time. In a way the early frosts upset the sugar level of the root, and subsequent frosts the starch content. The temporary enormous amount of sugar in the stem points to a large translocation of sugars from the roots.

The view is therefore accepted that the excess sugars found after frost in the aerial parts of the plant are not products of the photosynthesis, but translocated and mobilised from the root. It is doubtful whether this was a purposeful action on the part of the plant or whether the breakdown of the starch is due to uncontrollable influences of the meteorological conditions. The tendency of the root to return to the pre-frost level of starch seems to indicate rather that the plant itself is responsible, at least to some extent. On the other hand the very irregular starch curve in experiments in mid-winter point to diverse influences. One point has to be remembered. The experiments in 1945 were done with well established old lucerne which had enormous roots. If in this root system which weighs about 20 times as much as the aerial parts, 5 per cent. starch is dissolved and put into circulation in the stems and leaves, their sugar content increases to a terrific height. This very high sugar content would allow the formation of starch by diastase. The amount of sugar permitting condensation to starch is very small at high temperature (Czapek 1901).

The explanation of a translocation of sugars from the roots to the aerial parts has its parallel on some graphs and tables of Grandfield (1943, p. 40 ff.) where for North American conditions starch in the root of lucerne decreased up to 15 per cent. from October to January, sugars increased 10 per cent. in the same period, but most of it went to the crown buds where the sugar content in the same period increased 15 per cent., whilst starch decreased. By March, however, starch and total sugars were again on their normal level. According to Grandfield hydrolysis of starch and translocation of sugar occurred during the period when the plant was increasing in cold hardiness, and appeared to be a factor associated with the hardening process. At the same time more bound, less free water appeared in the crown buds.

It has been pointed out that no experiment as such could be repeated in the present investigation as the idea was to see what content of carbohydrates the plants had under natural conditions and how these carbohydrates could affect the grazing animal. Seasons in the continental climate of South Africa are dissimilar; the meteorological conditions, as such, also influence the ratio of the carbohydrates in the plant, and not only the direct assimilates, Thus it is no wonder that during the winter of 1945 plants were scarcely obtained with a small content of starch; on the contrary nearly all showed a high content of starch and sugars, which characterized the late winter and frost values of 1944. The amount of the different carbohydrates in the lucerne during winter is not only conditioned by season and temperature, but depends also on the general meteorological factors influencing the disposition (Stimmung) over which we have no control; in a similar way hydrolysis of starch in trees cannot be forced by low temperature at any time of the year, but only in the resting season.

From the foregoing it is obvious that after frost under the climatic conditions of Fauresmith there are large amounts of sugars present, particularly in the stems of the lucerne. In this respect the statement of different farmers of the district is interesting, viz. that they had never had any bloating during the winter months, but during summer. Yet in 1945 bloating was reported in the second half of September when ewes on the farm Grapfontein grazed on lucerne very early in the morning. The night before a very low temperature was recorded at Fauresmith. Thus the other statement may be due to different grazing management.

Conclusions.

Most of the former work on the ratio of the different sugars and starch in plants, has been done on large cut leaves exposed to light or darkness, dry or on wet filter paper. In an agricultural investigation one cannot choose an experimental plant for the sake of large leaves or such like, nor can one cut it except for a special purpose. It is obvious that in an uncut plant one cannot get, as migration is not prohibited, such clear results as with the "Blatthälftenmethode" of cut plants. Yet some results obtained with cut plants may be applicable to the uncut lucerne. In comparison with older literature (Ahrns 1922 and Iljin 1930) one has to take the change of methods into consideration. As was pointed out acid hydrolysis of sugars can give values for sugars 300 per cent. too high. Thus the present values obtained by the use of enzymes are lower. Moreover in these papers (Ahrns 1922) the changes in the carbohydrates were recorded once after a definite period of 24 hours either in the light or dark, dry or moist. It certainly produced very neat results but they cannot be directly applied to a standing plant where translocation takes place at any moment and where light and darkness follow one another. Thus the older papers merely indicate what to look for. It is only from Vasiliew and Vasiliew's (1936) paper where a suggestion is made as to what to expect over a longer period.

There is no doubt of the disappearance of starch in wilted and wilting lucerne. The disappearance is certainly accelerated by low temperature. Yet, it is equally obvious that during summer nights wilted, let alone fresh lucerne, can scarcely be found without any starch. To the dissolution of starch during wilting can be added its disappearance in frosted plants in which it is often accompanied as well by a non-formation in photosynthesis as a result of the low temperature. Frosting is so nearly related to wilting that this result is not surprising.

Yet here a restriction has to be made immediately being independent of light—therefore not a photosynthetic process— starch may be formed at a low temperature in leaves and particularly in stems if the sugar concentration is high enough. (See also Czapek 1901). The sugar from which the starch is formed in the aerial parts of the lucerne after heavy frosts is to the smallest extent only a product of assimilation, while the major portion is mobilised and translocated from the roots, where large amounts of starch are hydrolysed after frost.

Repeated drooping, trampling by animals or damage by insects lead to a very low starch content, presumably more through non-formation and not as much by hydrolysis of existing starch. The result following trampling is rather surprising, as all exterior conditions as well as the water content of the plant are favourable for photosynthetic activities.

The next point to be considered is the appearance of sucrose during the first wilting. According to Ahrns this sucrose appears mostly in the dark, originating quantitatively from the dissolving starch. In his opinion very little is produced in the light. In view of Kohler's investigation on the simultaneous formation of different sugars during photosynthetic activity the above view has probably to be revised. In the present investigation sucrose was practically always present although at times, only in very small amounts. But it decidedly increased in wilting during the day, and more so at night. It is quite likely that it has a double origin, (*a*) as direct assimilate, (*b*) by hydrolysis of starch and conversion of other sugars under the influence of wilting. If (*b*) is the only source, one could really ask why sucrose is not kept at a high level right through the wilting process. Instead of this sucrose generally accumulates only for a few hours, after which it gives way to an increase of monosaccharides. It is more than likely that Ahrns in his experiment never went beyond the sucrose stage, or that in cut-off leaves the trend is different. In cut-off shoots of lucerne this was not found to be the case. (Table 7). Values for the dominating reducing sugars were observed by Vasiliew and Vasiliew. Their source is also twofold, (*a*) as direct assimilate and (*b*) due to hydrolysis of polysaccharides in progressive wilting. In a long progressive wilting experiment a stage is reached at which there is no further accumulation of monosaccharides. Either they are translocated, with the stems always a step behind in their carbohydrate value as compared with the leaves, or they are used up in respiration. Just before death there may again be an accumulation of starch and sugars, but in this case it is chiefly sucrose.

Although a number of external factors lead to a low starch value, only drought and frost actually produce high sugar values. Other factors like trampling or damage by insects presumably decrease photosynthesis as such, not only the formation of starch, whilst drought and frost favour hydrolysis. Translocation as such does not seem to suffer for any length of time neither does it cause after-effects for a period longer than that occupied by the low temperature.

Hydrolysis and translocation of starch take place very quickly, as shown by the rapid changes in the percentage of the different carbohydrates in the various organs during a period of 30 hours. It is surprising that the changes are actually the quickest at low temperature; dissolution of starch in summer nights is relatively slow and increases only at the lower temperatures after midnight.

From the foregoing pages it is clear that not all the sugar in the aerial parts of the lucerne has its origin in the photosynthetic process, but that part of it is translocated from the roots. This applies particularly to periods of frost. In addition it may also be true during the prelethal stages of wilted lucerne where, after a depletion of assimilates, starch and sugar reappear suddenly just before death. In both cases the chloroplasts would seem to act as formers of the starch only when high sugar concentrations are present as found in a leaf lying on a solution of saccharose in the dark.

It has been stated that the formation of starch as photosynthetic process is more dependent on the water content than on the temperature. Yet temperature may in the long run be the deciding factor in explaining variations in the starch content under optimal water condition. For photosynthetic starch formation the temperature must be at least 6-8° C. Thus far is was assumed that under optimal conditions of water and light the formation of starch would go parallel with the optimum curve for assimilation, i.e. it should increase up to about 33° C. and then slow down. Evidence from Europe, however, shows this to be an erroneous view, as the starch maximum is already reached at 20° C. (Czapek 1921, p. 482). It is quite likely that the optimum temperature for starch formation in the warmer climate of South Africa is somewhat higher than the European temperature, but it is equally feasible that at higher temperatures less starch is formed than at 25° C. This would explain why at the highest temperatures lower starch values are found in the leaves than at lower temperatures.

What is not known is how prolonged high temperatures affect the whole enzymatic process of starch formation. The possibility exists that during the very hot summer months high starch values cannot be expected.

LITERATURE.

AHRNS, WALTER (1924). Weitere Untersuchungen über die Abhangigkeit des gegenseitigen Mengenverhältnisses der Kohlenhydrate im Laubblatt vom Wassergehalt. *Botanisches Archiv*, Vol. 5, pp. 234–259.

ARCHBOLD, H. K., AND MUKERJEE, B. N. (1942). Physiological studies in Plant nutrition, XII. Carbohydrate changes in several organs of the Barley plant during growth, with special reference to the development and ripening of the ear. *Annals of Botany N.S.* Vol. 6, pp. 1–41.

BARNELL, H. R. (1936). Seasonal changes in the carbohydrates of the wheat plant. *New Phytologist*. Vol. 35, pp. 229–66.

CZAPEK, F. (1901). Der Kohlehydrat-Stoffwechsel der Laubblätter im Winter. *Berichte der deutschen botanischen Gesellschaft*, Vol. 29, pp. 120–127.

CZAPEK, F. (1913). Biochemie der Pflanzen, Vol. I. Jena. G. Fischer.

DÉHÉRAIN, P. P., AND DUPONT, C. (1901). Sur l'origine de l'amidon du grain du blé. *Comptes rendus*, Vol. 133, p. 774.

GRANDFIELD, C. O. (1943). Food reserves and their translocation to the crown buds as related to cold and drought resistance in Alfalfa. *Journal of Agricultural Research*, Vol. 67, pp. 33–48.

HENRICI, M. (1943). Data on the sugar and starch content of some fodder plants under different physiological conditions. *South African Journal of Science*, Vol. 40, pp. 157–161.

HENRICI, M. (1944). The effect of wilting on the direct assimilates of lucerne and other fodder plants. *S.A. Association for Advancement of Science*, No. 41.

ILJIN, W. S. (1930). Der Einfluss des Welkens auf den Ab- und Aufbau der Stärke in der Pflanze. *Planta*, Vol. 10, pp. 170–184.

KLEIN, G. (1932). Handbuch der Pflanzenanalyse, II/I. Springer, Berlin.

KOHLER, GEORGE O. (1944). The effect of growth on the chemistry of the grasses. *Journal of Biological Chemistry*, Vol. 152, pp. 215–223.

LIDFORSS, BENGT (1907). Die wintergrüne Flora. Eine biologische Untersuchung. *Lunds Universitets Arsskrift*. N.F. 2, Afd. 2, S. 1–76.

Official and tentative methods of analyses of the Association of Agricultural Chemists (1925), Washington. 2nd Edition.

SMITH, JAMES H. C. (1944). Concurrency of carbohydrate formation and carbon dioxide absorption during photosynthesis in sunflower leaves. *Plant Physiology*, Vol. 19, pp. 394–403.

VAN DER PLANCK, J. E. (1937). A Modification of the Harding and Downs copper reagent, *Biochemical Journal*, Vol. 30, p. 157.

VASILIEW, I. M., AND VASILIEW, M. G. (1936). Changes in carbohydrate content of wheat plants during the process of hardening for drought resistance. *Plant Physiology*, Vol. II, pp. 115–125.

VOIGTLÄNDER, HANS (1909). Unterkühlung und Kältetod der Pflanzen. *Beitrage zur Biologie der Pflanzen*, Vol. 9, pp. 359–414.

TABLE 1.

Sugar and Starch Content of Normal Fresh Lucerne.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.							Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.	Fibre content.				
2322	13/1/42	Midday	H	4·00	4·49	0·45	4·04	—	—	—	—	—	Very good quality; pre-flowering stage.	—
2323	13/1/42	,,	H	2·67	4·52	0·56	3·96	0·50	0·06	—	—	—	Poor quality, pre-flowering stage.	—
2325	28/1/42	,,	H	3·07	—	0·37	—	—	—	—	—	—	Fresh, sundried....	—
2329	10/2/42	,,	H	4·50	2·30	0·38	1·92	—	—	—	—	—	Cut in sun, after rain. Second cut. Oven dried.	—
2330	26/2/42	Afternoon	H	5·09	1·29	1·30	0·00	—	—	—	—	—	Cut in sun after rain. Sundried.	—
2331	26/3/42	,,	H	5·97	1·58	1·58	0·00	—	—	—	—	—	Sundried.........	—
2334	27/4/42	,,	H	4·91	1·25	1·25	0·00	1·25	0·00	—	86·90	—	—	—
2390	25/1/43	,,	H	5·11	2·34	1·07	1·27	0·95	0·32	—	86·90	—	About a foot high	—
2433	19/3/43	12 a.m.	H	2·02	1·95	0·90	1·05	0·81	0·09	—	77·60	Stems	—	—
2435	—	7 p.m.	H	2·52	1·29	1·16	0·13	0·93	0·23	—	75·20	Stems	—	—
2437	—	12 p.m.	H	2·33	2·36	0·81	1·55	0·78	0·03	—	86·40	Stems	—	—
2439	20/3/43	7 a.m.	H	2·02	1·51	1·24	0·27	1·24	0·00	42·58	78·90	Stems	—	—
2434	19/3/43	12 a.m.	H	4·06	1·84	1·26	0·58	1·20	0·06	16·58	77·60	Leaves	—	—
2436	—	7 p.m.	H	6·32	1·88	1·33	0·55	0·96	0·37	—	75·20	Leaves	—	—
2438	—	12 p.m.	H	5·58	1·16	1·05	0·11	1·05	0·00	—	86·40	Leaves	—	—
2440	20/3/43	7 a.m.	H	3·20	0·80	0·43	0·37	0·39	0·04	—	78·90	Leaves	—	—
2441	20/3/43	7 a.m.	H	6·17	—	2·98	—	3·00	0·00	—	—	Flowers	—	—
2596	11/10/43	12 a.m.	H	3·21	1·57	—	—	—	—	25·86	72·37	Stems	—	—
2598	—	7 p.m.	H	2·07	1·79	1·71	0·08	—	—	—	76·51	Stems	—	—
2600	—	12 p.m.	H	2·00	2·26	2·23	0·03	—	—	—	75·51	Stems	—	—
2602	12/10/43	7 a.m.	H	1·71	1·08	0·86	0·22	—	—	—	85·60	Stems	—	—
2597	11/10/43	12 a.m.	H	3·56	2·10	1·65	0·45	—	—	16·06	72·37	Leaves	—	—
2599	—	7 p.m.	H	6·62	1·58	1·09	0·49	—	—	—	76·51	Leaves	—	—
2601	—	12 p.m.	H	4·09	0·96	0·38	0·58	—	—	—	75·51	Leaves	—	—
2603	12/10/43	7 a.m.	H	1·65	1·06	0·41	0·65	—	—	—	85·66	Leaves	—	—
2423	22/2/43	—	P	1·54	2·04	0·80	1·24	0·80	0·00	—	80·10	Stems	—	—
2424	22/2/43	—	P	5·12	1·92	0·69	1·23	0·70	0·00	—	80·10	Leaves	—	—
2326	30/1/42	—	P	3·30	1·39	0·35	1·04	—	—	—	—	Total	Oven dried.......	—
2328	30/1/42	—	P	4·07	1·24	1·20	0·04	—	—	—	—	Total	Sundried.........	—
2333	26/3/42	—	P	5·07	3 87	0·50	3·37	0·47	0·03	—	—	Total	Sundried.........	—
2335	27/3/42	—	P	5·83	1·97	0·82	1·15	0·80	0·02	—	—	Total	Sundried.........	—
2355	27/10/42	—	P	4·37	1·29	0·57	0·72	—	—	—	75·00	Total	Killed in alcohol..	—
2389	14/1/43	—	P	4·76	1·30	0·50	0·80	0·37	0·12	—	86·40	Total	Killed in alcohol, about a ft. high	—

TABLE 1 (*continued*).

Sugar and Starch Content of Normal Fresh Lucerne.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter. Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.	Fibre content.	Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
2418	16/2/43	—	P	2·17	1·45	0·96	0·49	0·87	0·09	—	80·00	Stems	—	—
2420	16/2/43	—	P	3·48	1·55	1·04	0·51	0·96	0·08	—	80·00	Leaves	—	—
2442	22/3/43	12 a.m.	P	2·92	1·94	1·34	0·60	0·93	0·41	42·54	74·40	Stems	—	—
2445	—	7 p.m.	P	1·58	2·14	1·36	1·78	1·00	0·36	—	78·60	Stems	—	—
2448	—	12 a.m.	P	0·90	1·74	0·86	0·88	0·86	0·00	—	71·70	,,	—	—
2451	23/3/43	7 a.m.	P	2·14	1·49	1·29	0·20	1·17	0·12	—	81·30	,,	—	—
2443	22/3/43	12 a.m.	P	7·62	3·27	1·09	2·18	0·62	0·47	12·60	74·40	Leaves	—	—
2446	—	7 p.m.	P	4·91	2·69	0·95	1·74	0·95	0·00	—	78·60	,,	—	—
2449	—	12 p.m.	P	3·59	0·81	0·81	0·00	0·71	0·10	—	71·70	,,	—	—
2452	23/3/43	7 a.m.	P	2·54	1·27	1·27	0·00	1·10	0·12	—	81·30	,,	—	—
2444	22/3/43	12 a.m.	P	2·75	—	1·27	—	0·71	0·56	—	—	Flowers	—	—
2447	—	7 p.m.	P	6·97	—	1·61	—	1·41	0·20	—	—	,,	—	—
2450	—	12 p.m.	P	5·14	1·30	1·09	0·21	1·09	0·00	—	—	,,	—	—
2453	23/3/43	7 a.m.	P	1·56	—	2·02	—	—	—	—	—	,,	—	—
2572	7/10/43	12 a.m.	P	1·40	2·16	1·86	0·30	—	—	39·41	74·45	Stems	—	—
2574	—	8 p.m.	P	1·71	2·22	1·36	0·86	—	—	—	69·68	,,	—	—
2576	—	12 p.m.	P	1·08	2·28	1·26	1·02	—	—	—	76·88	,,	—	—
2578	8/10/43	7 a.m.	P	1·12	2·32	1·09	1·23	—	—	—	74·96	,,	—	—
2573	7/10/43	12 a.m.	P	2·78	2·13	1·98	0·15	—	—	16·16	74·45	Leaves	—	—
2575	—	8 p.m.	P	2·69	2·14	1·31	0·83	—	—	—	69·68	,,	—	—
2577	—	12 p.m.	P	2·32	2·17	0·89	1·28	—	—	—	76·88	,,	—	—
2579	8/10/43	7 a.m.	P	2·34	2·15	2·17	0·00	—	—	—	74·96	,,	—	—
2762	22/3/44	8 a.m.	P	1·68	1·33	0·81	0·52	—	—	—	74·53	Stems	—	0·77
2764	—	1 p.m.	P	2·33	2·23	1·62	0·61	—	—	—	72·52	,,	—	—
2766	—	4 p.m.	P	1·75	1·73	1·15	0·58	—	—	37·34	63·21	,,	—	—
2768	—	8 p.m.	P	2·00	1·70	1·51	0·19	—	—	—	60·29	,,	—	—
2770	—	12 p.m.	P	1·44	1·56	1·41	0·15	—	—	—	66·23	,,	—	—
2772	23/3/44	7 a.m.	P	1·77	1·97	1·28	0·69	—	—	—	75·51	,,	—	—
2774	—	11 a.m.	P	1·89	1·41	1·41	0·00	—	—	—	70·38	,,	—	—
2763	22/3/44	8 a.m.	P	2·32	1·35	1·06	0·29	—	—	—	74·53	Leaves	—	—
2765	—	1 p.m.	P	2·69	1·89	0·91	0·98	—	—	—	72·52	,,	—	—
2767	—	4 p.m.	P	2·67	1·10	0·67	0·43	—	—	15·64	63·21	,,	—	—
2769	—	8 p.m.	P	2·55	1·40	1·43	0·00	—	—	—	60·29	,,	—	—
2771	—	12 p.m.	P	1·46	1·36	1·11	0·25	—	—	—	66·23	,,	—	—
2773	23/3/44	7 a.m.	P	1·96	1·32	0·73	0·59	—	—	—	75·51	,,	—	—
2775	—	11 a.m.	P	2·13	1·47	0·95	0·52	—	—	—	70·38	,,	—	—

TABLE 1 (*continued*).

Sugar and Starch Content of Normal Fresh Lucerne.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.							Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.	Fibre content.				
2874	20/4/44	12 a.m.	H	5·81	1·91	1·00	0·91	—	—	13·12	69·06	Leaves	Pot experiment....	—
2876	—	7 p.m.	H	7·95	2·63	0·98	1·65	—	—	—	68·84	,,	,, ,, ...	—
2878	—	12 p.m.	H	5·82	2·20	1·02	1·18	—	—	—	70·56	,,	,, ,, ...	—
2880	21/3/44	7 a.m.	H	4·31	1·36	1·17	0·19	—	—	—	71·28	,,	,, ,, ...	—
2882	—	12 a.m.	H	4·72	3·33	1·68	1·65	—	—	—	70·89	,,	,, ,, ...	—
2875	20/4/44	12 a.m.	H	—	4·12	1·39	2·73	—	—	32·52	69·06	Stems	,, ,, ...	—
2877	—	7 p.m.	H	—	3·09	1·12	1·97	—	—	—	68·84	,,	,, ,, ...	—
2879	—	12 p.m.	H	—	2·89	1·26	1·63	—	—	—	70·56	,,	,, ,, ...	—
2881	21/4/44	7 a.m.	H	—	2·35	0·98	1·37	—	—	—	71·28	,,	,, ,, ...	—
2883	—	12 a.m.	H	—	2·95	0·91	2.04	—	—	—	70·89	,,	,, ,, ...	—
3051	28/12/44	6 a.m.	P	5·32	1·07	1·05	0·00	—	—	—	70·10	Leaves	Fresh, just coming into bloom	—
3073	—	12.17 p.m.	P	6·97	1·53	0·93	0·60	—	—	—	69·44	,,	—	0·86
3085	—	8.10 p.m.	P	7·05	1·45	0·76	0·69	—	—	—	69·59	,,	Slightly drooping.	—
3089	29/12/44	12.30 a.m.	P	7·75	0·79	0·78	0·01	—	—	—	72·21	,,	Fresh, better than in evening	—
3099	—	6.10 a.m.	P	5·48	1·27	0·79	0·48	—	—	—	70·29	,,	Fresh.............	—
3052	28/12/44	6.00 a.m.	P	3·67	1·70	1·17	0·53	—	—	—	70·10	Stems	Fresh.............	—
3074	—	12.17 p.m.	P	6·76	1·93	1·13	0·80	—	—	—	69·44	,,	Fresh.............	—
3086	—	8.10 p.m.	P	5·21	1·73	0·85	0·88	—	—	—	69·59	,,	Slightly drooping..	—
3090	29/12/44	12.30 a.m.	P	3.97	1·57	0·75	0·82	—	—	—	72·21	,,	Fresh.............	—
3100	—	6.10 a.m.	P	4·86	1·49	0·82	0·67	—	—	—	70·29	,,	Fresh.............	—

6241—9

TABLE 2.

Sugar and Starch Content of Temporarily Wilted Lucerne.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.							Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.	Fibre content.				
2421	20/2/43	—	P	0·84	1·66	0·72	0·94	0·66	0·06	—	80·12	Leaves	Watered on the 18/2/43	—
2422	20/2/43	—	P	2·46	1·81	0·83	0·98	0·72	0·11	—	80·12	Stems	—	—
2423	22/2/43	—	P	1·54	2·04	0·76	1·28	0·76	0·00	—	80·01	,,	—	—
2424	22/2/43	—	P	5·12	1·92	0·69	1·23	0·69	0·00	—	80·01	Leaves	—	—
2588	12/10/43	12 a.m.	P	1·29	2·29	1·89	0·40	—	—	32·76	66·50	Stems	—	—
2590	—	7 p.m.	P	1·80	3·20	1·44	1·76	—	—	—	73·19	,,	—	—
2592	—	12 p.m.	P	3·24	3·17	1·90	1·27	—	—	—	71·48	,,	—	—
2594	13/10/43	7 a.m.	P	2·41	3·29	1·96	1·33	—	—	—	74·08	,,	—	—
2589	12/10/43	12 a.m.	P	2·76	1·27	1·14	0·13	—	—	18·20	66·50	Leaves	—	—
2591	—	7 p.m.	P	3·84	2·11	0·89	1·22	—	—	—	73·19	,,	—	—
2593	—	12 p.m.	P	2·99	1·65	1·45	0·20	—	—	—	71·48	,,	—	—
2595	13/10/43	7 a.m.	P	2·02	1·67	1·38	0·19	—	—	—	74·08	,,	—	—
2612	12/10/43	12 a.m.	H	2·10	3·30	2·17	1·13	—	—	31·96	69·90	Stems	Just drooping.....	—
2614	—	7 p.m.	H	3·61	1·82	0·52	1·30	—	—	—	70·96	,,	—	—
2616	—	12 p.m.	H	3·64	2·88	2·27	0·61	—	—	—	78·80	,,	—	—
2618	13/10/43	7 a.m.	H	3·15	0·97	0·42	0·55	—	—	—	66·00	,,	—	—
2613	12/10/43	12 a.m.	H	4·21	1·05	0·45	0·60	—	—	18·72	69·90	Leaves	—	—
2615	—	7 p.m.	H	4·52	0·74	0·39	0·35	—	—	—	70·96	,,	—	—
2617	—	12 p.m.	H	4·59	2·13	1·47	0·66	—	—	—	78·80	,,	—	—
2619	13/10/43	7 a.m.	H	5·37	3·34	2·01	1·33	—	—	—	66·00	,,	—	—
3041	22/12/44	12 a.m.	H	2·77	0·93	0·88	0·05	—	—	—	67·27	Leaves	Pots..............	1·20
3043	—	8 p.m.	H	2·95	0·93	0·86	0·07	—	—	—	52·65	,,	—	—
3045	23/12/44	12.20 a.m.	H	2·21	1·04	0·96	0·08	—	—	—	57·94	,,	Drooping badly...	—
3047	—	5.00 a.m.	H	1·66	1·39	0·58	0·81	—	—	—	69·67	,,	Drooping.........	—
3049	23/12/44	11.40 a.m.	H	0·73	1·25	1·22	0·03	—	—	—	54·11	Leaves	Badly wilted......	—
3042	22/12/44	12 a.m.	H	1·39	2·28	1·51	0·77	—	—	—	67·27	Stems	—	—
3044	—	8 p.m.	H	2·09	1·71	1·37	0·34	—	—	—	52·65	,,	—	—
3046	23/12/44	12.20 a.m.	H	0·78	3·03	1·29	1·74	—	—	—	57·94	,,	—	—
3048	—	5 a.m.	H	2·03	1·71	1·13	0·58	—	—	—	69·67	,,	—	—
3050	—	11.40 a.m.	H	0·28	1·54	1·40	0·14	—	—	—	54·11	,,	Badly wilted......	—

TABLE 3.

Sugar and Starch Content of Lucerne which was allowed to Wilt and Recover.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.							Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.	Fibre content.				
2321	12/1/42	Noon	H	1·60	—	0·30	—	—	—	—	—	Whole	Cut when wilted.	—
2395	27/1/43	Noon	H	1·85	3·49	1·32	2·17	0·90	0·42	—	67·50	,,	Cut when wilted. Allowed to wilt four times	—
2393	27/1/43	Noon	P	2·78	3·80	1·25	2·55	1·25	0·00	—	67·40	Leaves	Wilted and allowed to recover. Poor.	—
2421	20/2/43	Noon	P	0·84	2·74	1·08	1·66	—	—	—	80·00	,,	Wilted and recovered	—
2422	20/2/43	Noon	P	2·45	2·93	1·12	1·81	1·12	0·00	—	80·00	Stems	,, ,, ,,	—
2894	21/2/44	12 a.m.	H	—	1·54	0·63	0·91	—	—	—	66·12	Leaves	Four times wilted and recovered; temporary wilted	—
2895	—	7 p.m.	H	4·96	1·14	0·86	0·28	—	—	—	69·10	,,	,, ,,	—
2896	22/2/44	7 a.m.	H	0·33	1·25	0·68	0·57	—	—	22·04	71·72	,,	,, ,,	—
2898	—	12 a.m.	H	—	1·70	0·70	1·00	—	—	—	64·12	,,	,, ,,	—
2894a	21/2/44	12 a.m.	H	—	1·46	0·71	0·75	—	—	—	66·12	Stems	,, ,,	—
2895a	—	7 p.m.	H	—	2·78	0·72	2·06	—	—	—	69·10	,,	,, ,,	—
2897	22/2/44	7 a.m.	H	6·12	1·14	0·87	0·27	—	—	36·20	71·72	,,	,, ,,	—
2899	—	12 a.m.	H	—	4·22	0·55	3·67	—	—	—	64·12	,,	,, ,,	—
2927	2/12/43	12 a.m.	H	2·35	2·78	1·15	1·63	—	—	18·40	52·88	Leaves	,, ,,	—
2929	—	8 p.m.	H	1·46	2·42	1·00	1·42	—	—	—	49·88	,,	,, ,,	—
2931	—	12 p.m.	H	1·61	2·78	1·10	1·68	—	—	—	41·87	,,	,, ,,	—
2933	3/12/43	7 a.m.	H	1·60	3·21	1·02	2·19	—	—	—	46·36	,,	,, ,,	—
2928	2/12/43	12 a.m.	H	1·17	3·21	1·06	2·15	—	—	44·44	52·88	Stems	,, ,,	—
2930	—	8 p.m.	H	1·74	2·54	0·87	1·67	—	—	—	49·88	,,	,, ,,	—
2932	—	12 p.m.	H	1·71	3·44	1·39	2·05	—	—	—	41·87	,,	,, ,,	—
2934	3/12/43	7 a.m.	H	1·26	2·78	1·20	1·58	—	—	—	46·36	,,	,, ,,	—

TABLE 4.

Sugar and Starch Content of Permanently Wilted Lucerne.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.							Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.	Fibre content.				
2324	22/1/42	Noon	H	0·59	3·87	0·50	3·37	0·50	0·00	—	—	Total	Left 8 days without water; wilted	—
2394	27/1/43	Noon	H	2·90	1·31	0·54	0·77	0·37	0·17	—	41·30	Total	—	—
2604	8/10/43	12 a.m.	H	0·65	2·95	2·24	0·71	—	—	34·60	53·59	Stems	—	—
2606	—	7 p.m.	H	0·93	2·12	1·56	0·56	—	—	—	69·04	,,	—	—
2608	—	12 p.m.	H	1·40	3·17	1·92	1·25	—	—	—	62·33	,,	—	—
2610	9/10/43	7 a.m.	H	1·78	1·84	1·38	0·46	—	—	—	60·53	,,	—	—
2605	8/10/43	12 a.m.	H	1·18	1·82	0·77	1·05	—	—	18·60	53·59	Leaves	—	—
2607	—	7 p.m.	H	0·45	1·19	0·56	0·63	—	—	—	69·04	,,	—	—
2609	—	12 p.m.	H	0·44	0·89	0·87	0·02	—	—	—	62·33	,,	—	—
2611	9/10/43	7 a.m.	H	1·44	1·22	1·02	0·20	—	—	—	60·53	,,	—	—
2392	27/1/43	Noon	P	2·78	2·64	1·32	1·32	0·77	0·55	—	64·40	Total	—	—
2417	18/2/43	Noon	P	3·73	1·53	0·78	0·75	0·68	0·10	—	—	Stems	—	—
2419	18/2/43	Noon	P	2·02	1·60	0·66	0·94	0·55	0·11	—	—	Leaves	—	—
2580	22/10/43	12 a.m.	P	1·15	1·92	1·92	0·00	—	—	34·32	63·10	Stems	—	—
2582	—	7 p.m.	P	0·96	1·57	1·50	0·07	—	—	—	65·10	,,	—	—
2584	—	12 p.m.	P	1·29	2·04	1·93	0·11	—	—	—	63·80	,,	—	—
2586	23/10/43	7 a.m.	P	1·06	2·25	2·01	0·24	—	—	—	49·11	,,	—	—
2581	22/10/43	12 a.m.	P	0·83	0·87	0·82	0·05	—	—	20·88	63·17	Leaves	—	—
2583	—	7 p.m.	P	1·22	1·75	—	—	—	—	—	65·12	,,	—	—
2585	—	12 p.m.	P	1·80	1·52	1·52	0·00	—	—	—	63·80	Leaves	—	—
2587	23/10/43	7 a.m.	P	0·85	1·78	1·49	0·29	—	—	—	49·11	,,	—	—
2884	10/1/44	12 a.m.	H	2·04	1·46	0·74	0·72	—	—	15·64	46·66	Leaves	Pot experiment....	—
2886	—	7 p.m.	H	2·28	1·56	0·69	0·87	—	—	—	40·06	,,	—	—
2888	—	12 p.m.	H	1·65	1·54	1·02	0·52	—	—	—	52·82	,,	—	—
2890	11/1/44	7 a.m.	H	0·69	1·88	0·85	1·03	—	—	—	36·51	,,	—	—
2892	—	12 a.m.	H	2·74	1·49	0·63	0·86	—	—	—	35·34	,,	—	—
2885	10/1/44	12 a.m.	H	0·30	2·71	0·93	1·78	—	—	36·06	46·66	Stems	—	—
2887	—	7 p.m.	H	0·08	2·61	0·90	1·71	—	—	—	40·06	,,	—	—
2889	—	12 p.m.	H	1·36	2·20	0·74	1·46	—	—	—	52·82	,,	—	—
2891	11/1/44	7 a.m.	H	0·27	2·70	0·80	1·90	—	—	—	36·51	,,	—	—
2893	—	12 a.m.	H	0·69	2·33	0·80	1·53	—	—	—	35·34	,,	—	—

TABLE 4 (*continued*).

Sugar and Starch Content of Permanently Wilted Lucerne.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.							Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.	Fibre content.				
3014	1/12/44	11.25 a.m.	H	1·77	2·33	1·13	1·20	—	—	16·80	44·53	Leaves	Wilted, pot experiment	—
3015	1/12/44	11.25 a.m.	H	2·71	3·58	1·37	2·21	—	—	34·66	—	Stems	Wilted...........	—
3016	1/12/44	8.10 p.m.	H	0·53	2·08	0·93	1·15	—	—	—	53·44	Leaves	Drooping.........	—
3017	1/12/44	8.10 p.m.	H	0·89	2·28	1·21	1·07	—	—	—	—	Stems	,, ...	—
3022	2/12/44	1.00 a.m.	H	2·19	—	—	—	—	—	—	34·75	Leaves	More wilted than evening before	—
3023	2/12/44	1.00 a.m.	H	2·09	—	—	—	—	—	—	—	Stems	—	—
3018	2/12/44	5.10 a.m.	H	0·82	3·44	0·95	2·49	—	—	—	37·50	Leaves	Wilted...........	—
3019	2/12/44	5.10 a.m.	H	—	7·28	0·86	6·42	—	—	—	—	Stems	,, ...	—
3020	2/12/44	11.30 a.m.	H	—	4·12	1·04	3·08	—	—	—	42·00	Leaves	,, ...	—
3021	2/12/44	11.30 a.m.	H	—	6·43	1·02	5·41	—	—	—	—	Stems	,, ...	—
3053	28/12/44	6.00 a.m.	P	0·73	1·48	0·47	1·01	—	—	—	48·76	Leaves	Drooping.........	1·85
3071	—	12.17 p.m.	P	0·86	1·41	1·10	0·31	—	—	—	43·93	,,	Wilted...........	—
3083	—	8.10 p.m.	P	2·08	0·81	0·76	0·05	—	—	—	59·02	,,	,, ...	—
3087	29/12/44	12.30 a.m.	P	1·04	1·40	0·81	0·59	—	—	—	55·87	,,	,, ...	—
3101	—	6.10 a.m.	P	1·08	1·40	0·79	0·61	—	—	—	54·97	,,	,, ...	—
3054	28/12/44	6.00 a.m.	P	0·86	2·29	0·57	1·72	—	—	—	48·76	Stems	Drooping.........	—
3072	—	12.17 p.m.	P	1·68	1·83	1·10	0·73	—	—	—	43·93	,,	Wilted...........	—
3084	—	8.10 p.m.	P	1·45	2·67	0·86	1·81	—	—	—	59·02	,,	,, ...	—
3088	29/12/44	12.30 a.m.	P	1·68	2·20	0·82	1·38	—	—	—	55·87	,,	,, ...	—
3102	—	6.10 a.m.	P	1·55	2·36	0·68	1·68	—	—	—	54·97	,,	,, ...	—

TABLE 5.

Sugar and Starch Content of Damaged Lucerne.

No.	Date.	Time.	Variety.	In Percentage of Stove Dry Matter.							Water content in percentage. of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.	Fibre content.				
2648	7/12/43	Noon	H	4·71	2·38	1·99	0·39	—	—	—	65·27	Leaves	In bad condition, eaten by insects	—
2649	7/12/43	Noon	H	3·52	1·44	0·63	0·81	—	—	—	65·27	Stems	Eaten by insects..	—
2620	8/12/43	8 p.m.	H	1·13	1·23	0·22	1·01	—	—	41·30	71·47	,,	,, ,, ,, ..	—
2622	—	12 p.m.	H	1·24	0·54	0·54	0·00	—	—	—	71·03	,,	Best part of it on border	—
2624	9/12/43	7 a.m.	H	1·77	0·77	0·17	0·60	—	—	—	70·44	,,	,, ,,	—
2626	—	12 a.m.	H	0·91	0·26	0·24	0·02	—	—	—	68·01	,,	,, ,,	—
2628	—	8 p.m.	H	0·82	0·82	0·69	0·13	—	—	—	61·11	,,	,, ,,	—
2621	8/12/43	8 p.m.	H	3·52	1·00	0·56	0·44	—	—	20·84	71·47	Leaves	,, ,,	—
2623	—	12 p.m.	H	2·52	1·06	0·56	0·50	—	—	—	71·03	,,	,, ,,	—
2625	9/12/43	7 a.m.	H	2·65	1·04	0·52	0·52	—	—	—	70·44	,,	,, ,,	—
2627	—	12 a.m.	H	1·40	1·15	0·61	0·54	—	—	—	68·61	,,	,, ,,	—
2629	—	8 p.m.	H	3·21	1·76	0·52	1·24	—	—	—	65·27	,,	Looks a bit better, insects leaving	—
2630	9/12/43	12 a.m.	P	0·64	1·04	0·89	0·15	—	—	45·26	72·29	Stems	Lucerne on border, half eaten by insects	—
2632	—	7 p.m.	P	2·63	1·36	0·94	0·42	—	—	—	76·16	,,	,, ,,	—
2634	—	12 p.m.	P	0·78	1·31	0·48	0·83	—	—	—	70·75	,,	,, ,,	—
2636	10/12/43	7 a.m.	P	0·59	1·40	0·67	0·73	—	—	—	73·47	,,	,, ,,	—
2638	—	12 a.m.	P	0·72	1·64	1·02	0·52	—	—	—	73·85	,,	,, ,,	—
2631	9/12/43	12 a.m.	P	2·36	2·10	1·05	1·05	—	—	16·61	72·29	Leaves	,, ,,	—
2633	—	7 p.m.	P	2·06	1·54	0·92	0·62	—	—	—	76·16	,,	,, ,,	—
2635	—	12 p.m.	P	1·08	1·72	1·02	0·70	—	—	—	70·75	,,	,, ,,	—
2637	10/12/43	7 a.m.	P	1·76	1·54	1·11	0·43	—	—	—	73·47	,,	,, ,,	—
2639	—	12 a.m.	P	2·65	2·59	2·27	0·32	—	—	—	73·85	,,	,, ,,	—

TABLE 6.

Grazed Lucerne and Agricultural Samples.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.						Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fructose.	Glucose.				
2327	30/1/42	—	P	2·77	0·52	0·32	0·20	—	—	—	Total	Sweated..................	—
2328	30/1/42	—	P	4·07	1·24	1·20	0·04	—	—	—	,,	Sundried..................	—
2332	26/2/42	—	P	4·79	1·42	1·19	0·23	—	—	—	,,	Slightly wilted............	—
2454	2/4/43	—	P	1·00	0·69	0·54	0·15	0·40	0·14	—	Stems	Sweated, smells badly.... .	—
2455	2/4/43	—	P	0·80	1·42	0·49	0·93	0·47	0·02	—	Leaves	,, ,, ,, ...	—
2456	2/4/43	—	P	0·57	—	0·55	—	0·42	0·13	—	Flowers	,, ,, ,, ...	—
2738	25/2/44	12 a.m.	P	1·14	0·63	0·45	0·18	—	—	76·56	Stems	1 ft. high, trampled by sheep, fresh	—
2739	25/2/44	12 a.m.	P	2·26	0·46	0·46	0·00	—	—		Leaves	1 ft. high, trampled by sheep	2·22
2740	3/2/44	12 a.m.	P	1·19	0·58	0·31	0·27	—	—	73·57	Stems	1½ ft. high, trampled, fresh	—
2741	3/2/44	12 a.m.	P	0·91	1·59	0·92	0·67	—	—		Leaves	,, ,, ,, ...	1·73
2742	15/3/44	12 a.m.	H	0·56	0·96	0·50	0·46	—	—	80·75	Stems	4 in. high, trampled, fresh	—
2743	15/3/44	12 a.m.	H	2·39	0·51	0·43	0·09	—	—		Leaves	,, ,, ,, ...	0·41
2862	21/10/43	—	—	1·71	5·30	4·76	0·44	—	—	—	—	Dry lucerne causing bloating	—
2863	21/10/43	—	—	0·00	3·40	2·81	0·59	—	—	—	—	,, ,, ,, ,,	—

TABLE 7.

Sugar and Starch Content of Cut Lucerne Left in Water, Exposed to Sun or Left to Wilt.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.					Water content in percentage of fresh mat.	Organ.	Condition.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fibre.				
2776	22/3/44	8 a.m.	P	1·56	2·49	1·56	0·93	—	74·53	Stems	Fresh	0·78
2778	—	1 p.m.	P	2·12	1·98	1·45	0·53	45·14	68·29	,,	Slightly drooping	—
2780	—	4 p.m.	P	1·79	2·03	1·51	0·52	—	72·82	,,	Fresh	—
2782	—	8 p.m.	P	1·85	1·81	1·01	0·80	—	73·03	,,	,,	—
2784	—	12 p.m.	P	2·45	2·15	1·17	0·98	—	67·71	,,	,,	—
2786	23/3/44	7 a.m.	P	1·92	1·13	0·89	0·24	—	68·03	,,	,,	—
2788	—	11 a.m.	P	1·91	1·37	1·16	0·21	—	63·58	,,	,,	—
2777	22/3/44	8 a.m.	P	2·09	1·81	1·73	0·08	—	74·53	Leaves	,,	—
2779	—	1 p.m.	P	2·02	1·75	1·63	0·12	18·52	68·29	,,	Slightly drooping	—
2781	—	4 p.m.	P	2·01	1·37	1·06	0·31	—	92·82	,,	Fresh	—
2783	—	8 p.m.	P	2·31	1·27	0·64	0·63	—	73·03	,,	,,	—
2785	—	12 p.m.	P	1·59	1·43	1·10	0·33	—	67·71	,,	,,	—
2787	23/3/44	7 a.m.	P	1·52	1·49	1·10	0·39	—	68·03	,,	,,	—
2789	—	11 a.m.	P	1·48	1·20	1·13	0·07	—	63·58	,,	,,	—
2744	20/3/44	8 a.m.	H	1·49	1·20	0·87	0·33	43·46	69·40	Stems	Cut fresh, left in sun	—
2746	—	12 a.m.	H	1·83	2·10	1·10	1·00	—	61·35	,,	Half wilted, left in sun, cut	—
2748	—	4 p.m.	H	1·45	3·32	1·45	1·87	—	51·60	,,	,, ,, ,, ,, ,,	—
2750	—	7 p.m.	H	1·58	3·01	1·34	1·67	—	49·54	,,	Well wilted, left in sun, cut	—
2752	21/3/44	12.30 a.m.	H	1·49	2·32	0·76	1·56	—	41·24	,,	,, ,, ,, ,,	—
2754	—	6 a.m.	H	0·88	3·20	1·78	1·42	—	25·69	,,	Wilted, half dry, left in sun	—
2756	—	10 a.m.	H	1·41	2·34	1·92	0·42	—	20·68	,,	,, ,, ,, ,,	—
2758	—	2 p.m.	H	1·24	1·44	1·28	0·16	—	11·68	,,	Nearly dry, left in sun	—
2760	—	7 p.m.	H	0·89	2·89	1·45	1·44	—	9·24	,,	Nearly dry	—
2745	20/3/44	8 a.m.	H	1·89	1·52	0·80	0·72	15·66	69·40	Leaves	Fresh	—
2747	—	12 a.m.	H	1·28	1·46	1·13	0·33	—	61·35	,,	Half wilted, left in sun, cut	—
2749	—	4 p.m.	H	1·14	2·12	1·23	0·89	—	51·60	,,	,, ,, ,, ,,	—
2751	—	7 p.m.	H	1·16	1·41	0·83	0·58	—	49·54	,,	Well wilted, left in sun	—
2753	21/3/44	12.30 a.m.	H	1·42	1·56	0·97	0·59	—	41·24	,,	Well wilted	—
2755	—	6 a.m.	H	1·62	0·95	0·74	0·21	—	25·69	,,	Wilted, half dry, left in sun	—
2757	—	10 a.m.	H	1·44	1·05	0·67	0·38	—	20·68	,,	Wilted, half dry	—
2759	—	2 p.m.	H	2·17	1·32	1·20	0·12	—	11·68	,,	Nearly dry	—
2761	—	7 p.m.	H	0·79	1·36	1·03	0·33	—	9·24	,,	Nearly dry	—

TABLE 7 (*continued*).

Sugar and Starch Content of Cut Lucerne Left in Water, Exposed to Sun or Left to Wilt.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter. Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fibre.	Water content in percentage of fresh mat.	Organ.	Condition.	Ratio of leaves to stems.
3055	28/12/44	6 a.m.	P	3·18	1·77	0·34	1·43	—	70·57	Leaves	Fresh; cut for fresh cut experiment exposed to sun	—
3061	—	8 a.m.	P	5·13	1·69	0·52	1·17	—	66·99	,,	Cut, in water, slightly drooping....	—
3065	—	11 a.m.	P	4·56	2·27	0·53	1·74	—	64·30	,,	Fresh; cut, in water..............	—
3069	—	1 p.m.	P	5·55	1·79	0·81	0·98	—	—	,,	,, ,, ,, ...	—
3077	—	4 p.m.	P	5·57	1·91	0·99	0·92	—	65·59	,,	Slightly drooping, in water.........	—
3081	—	8 p.m.	P	4·01	0·87	0·89	0·00	—	74·45	,,	Fresh. In water..................	—
3093	29/12/44	1 a.m.	P	3·03	1·00	0·85	0·15	—	—	,,	,, ,, ...	—
3097	—	5.15 a.m.	P	3·31	1·15	0·94	0·21	—	67·73	,,	,, ,, ...	—
3103	—	8.10 a.m.	P	3·04	1·10	0·39	0·71	—	62·41	,,	,, ,, ...	—
3105	—	12 a.m.	P	2·10	1·97	0·84	1·13	—	76·63	,,	,, ,, ...	—
3056	28/12/44	6 a.m.	P	4·41	1·93	0·72	1·21	—	70·57	Stems	Fresh, cut for fresh cut experiment in sun	—
3062	—	8 a.m.	P	4·38	2·53	0·64	1·89	—	66·99	,,	Cut; in water; slightly drooping...	—
3066	—	11 a.m.	P	4·94	2·29	1·39	0·90	—	64·30	,,	,, ,, ,, ,, ...	—
3070	—	1 p.m.	P	2·02	2·09	1·10	0·99	—	—	,,	,, ,, ,, ,, ...	—
3078	—	4 p.m.	P	4·08	2·25	1·43	0·82	—	65·59	,,	,, ,, ,, ,, ...	—
3082	—	8 p.m.	P	1·51	2·32	0·97	1·35	—	74·45	,,	Stem in water....................	—
3094	29/12/44	1 a.m.	P	3·68	1·85	0·87	0·98	—	—	,,	Fresh............................	—
3098	—	5.15 a.m.	P	2·53	2·57	0·85	1·72	—	67·73	,,	,, ...	—
3104	—	8.10 a.m.	P	2·81	1·85	0·82	1·03	—	62·41	,,	,, ...	—
3106	—	12 a.m.	P	2·48	1·95	1·15	0·80	—	76·63	,,	,, ...	—
3057	28/12/44	6 a.m.	P	6·88	1·48	0·38	1·12	—	70·33	Leaves	Fresh. Cut for wilting experiment	—
3059	—	8 a.m.	P	3·21	2·09	0·51	1·58	—	60·84	,,	Drooping; without water..........	—
3063	—	11 a.m.	P	3·25	3·18	0·69	2·49	—	54·11	,,	Cut. Wilted lucerne..............	—
3067	—	1 p.m.	P	2·64	2·05	1·24	0·81	—	50·42	,,	,, ,, ...	—
3075	—	4 p.m.	P	3·68	1·91	0·99	0·92	—	10·36	,,	Wilted...........................	—
3079	—	8 p.m.	P	2·08	2·79	1·15	1·64	—	5·55	,,	Dry..............................	—
3091	29/12/44	1 a.m.	P	1·86	2·84	0·97	1·87	—	5·12	,,	Dry; Leaves falling from stems...	—
3095	—	5.15 a.m.	P	2·62	1·03	0·88	0·15	—	6·27	,,	,, ,, ,, ,, ...	—
3058	28/12/44	6 a.m.	P	3·80	1·49	0·38	1·11	—	70·33	Stems	Fresh; cut for wilting experiment..	—
3060	—	8 a.m.	P	4·12	1·73	0·69	1·04	—	60·84	,,	Drooping, without water...........	—
3064	—	11 a.m.	P	3·96	4·37	1·23	3·14	—	54·11	,,	Wilted stem......................	—
3068	—	1 p.m.	P	2·80	3·46	1·87	1·59	—	50·42	,,	,, ,, ...	—
3076	—	4 p.m.	P	2·31	3·64	1·26	2·38	—	10·36	,,	Wilted...........................	—
3080	—	8 p.m.	P	2·43	4·63	1·23	3·40	—	5·55	,,	Dry, leaves off stems.............	—
3092	29/1/44	1 a.m.	P	1·10	4·70	0·81	3·89	—	5·12	,,	,, ,, ,, ...	—
3096	—	5.15 a.m.	P	2·55	2·13	0·63	1·50	—	6·27	,,	,, ,, ,, ...	—

Table 8.

Lucerne Cut After Frost.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter. Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fibre.	Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
2852	22/5/44	12 a.m.	P	0·48	4·23	1·10	3·13	32·97	71·95	Stems	Cut after frost....................	—
2853	—	12 a.m.	P	1·95	2·62	1·60	1·02	16·16	71·95	Leaves	—	—
2854	—	7 p.m.	P	1·04	6·33	2·57	3·76	—	71·10	Stems	—	—
2855	—	7 p.m.	P	1·60	4·03	1·33	2·70	—	71·10	Leaves	—	—
2856	—	12 p.m.	P	0·71	6·54	2·76	3·78	—	67·66	Stems	—	—
2857	22/5/44	12 p.m.	P	0·05	3·23	3·06	0·17	—	67·66	Leaves	—	—
2858	23/5/44	7 a.m.	P	0·00	2·16	1·44	0·72	—	75·73	Stems	—	—
2859	—	7 a.m.	P	0·69	3·70	2·89	0·81	—	75·73	Leaves	—	—
2860	23/5/44	12 a.m.	P	0·00	2·68	1·71	0·97	—	69·76	Stems	—	—
2861	—	12 a.m.	P	1·49	3·09	1·49	1·60	—	69·76	Leaves	—	—
2864	30/8/44	12 a.m.	H	2·20	1·37	0·76	0·61	—	78·82	Leaves	—	—
2865	—	12 a.m.	H	2·02	—	0·81	—	—	78·82	Stems	—	—
2866	—	7 p.m.	H	1·16	1·80	1·58	0·22	—	76·97	Leaves	Cut after late frost...............	—
2867	—	7 p.m.	H	0·31	1·47	1·26	0·21	—	76·97	Stems	—	—
2868	—	12 p.m.	H	2·96	1·73	1·46	0·27	—	80·62	Leaves	—	—
2869	—	12 p.m.	H	2·77	1·25	1·18	0·07	—	80·62	Stems	—	—
2870	31/8/44	7 a.m.	H	1·50	1·80	1·71	0·09	—	79·56	Leaves	—	—
2871	—	7 a.m.	H	1·71	1·33	1·01	0·32	—	79·56	Stems	—	—
2872	—	12 a.m.	H	3·39	1·77	1·35	0·42	—	80·77	Leaves	—	—
2873	—	12 a.m.	H	1·43	1·54	1·24	0·30	—	80·77	Stems	—	—
2935	2/6/44	12 a.m.	H	3·47	4·43	2·20	2·23	16·04	72·27	Leaves	Drooping.........................	—
2936	—	12 a.m.	H	8·23	9·24	2·72	6·52	25·38	72·27	Stems	,, ...	—
2937	—	7 p.m.	H	6·58	3·82	2·22	1·60	—	72·12	Leaves	,, ...	—
2938	—	7 p.m.	H	5·51	6·56	3·16	3·40	—	72·12	Stems	,, ...	—
2939	—	12 p.m.	H	7·80	3·69	1·59	2·10	—	73·01	Leaves	,, ...	—
2940	—	12 p.m.	H	8·44	5·40	2·61	2·79	—	73·01	Stems	,, ...	—
2941	3/6/44	7 a.m.	H	2·16	2·74	1·95	0·79	—	71·78	Leaves	,, ...	—
2942	—	7 a.m.	H	4·50	5·07	2·06	3·01	—	71·78	Stems	,, ...	—
2943	—	12 a.m.	H	6·43	2·33	1·88	0·45	—	73·03	Leaves	,, ...	—
2944	—	12 a.m.	H	5·24	5·53	2·68	2·85	—	73·03	Stems	,, ...	—
3004	23/8/44	12 a.m.	H	5·55	5·04	2·70	2·34	—	74·40	Leaves	In pots. Cut after late frost......	0·70
3005	—	12 a.m.	H	6·06	4·12	1·84	2·28	—	74·40	Stems	,, ,, ,, ,,	—
3006	—	7 p.m.	H	8·00	4·13	1·69	2·45	—	69·30	Leaves	,, ,, ,, ,,	—
3007	—	7 p.m.	H	4·87	5·05	2·35	2·70	—	69·30	Stems	,, ,, ,, ,,	—
3008	—	12 p.m.	H	5·74	3·50	1·96	1·54	—	77·46	Leaves	,, ,, ,, ,,	—
3009	—	12 p.m.	H	4·05	3·08	1·73	1·35	—	77·46	Stems	,, ,, ,, ,,	—

TABLE 8 (*continued*).

Lucerne Cut After Frost.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.					Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fibre.				
3010	24/8/44	7 a.m.	H	6·52	5·00	2·48	2·52	—	67·92	Leaves	In pots. Cut after late frost	—
3011	—	7 a.m.	H	3·77	5·16	2·13	3·03	—	67·92	Stems	,, ,, ,, ...	—
3012	—	12 a.m.	H	6·08	4·70	2·76	1·94	—	67·08	Leaves	—	0·70
3013	—	12 a.m.	H	1·89	7·49	3·09	4·40	—	67·08	Stems	—	—
3224	14/5/45	12.20 p.m.	P	3·91	3·87	2·16	1·71	—	72·18	Leaves	Slightly wilted, after two nights' frost; in good condition. In plot	1·00
3225	—	—	P	3·26	3·77	1·91	1·86	—	,,	Stems	—	0·88
3226	—	—	P	10·51	7·87	6·50	1·37	—	—	Roots	—	4·92
3227	14/5/45	7.45 p.m.	P	4·04	5·31	3·70	1·61	—	83·41	Leaves	Slightly wilted....................	—
3228	—	—	P	4·43	5·77	4·38	1·39	—	,,	Stems	—	—
3229	—	—	P	7·86	8·83	7·22	1·61	—	—	Roots	—	—
3230	15/5/45	12.05 a.m.	P	5·45	4·95	3·97	0·98	—	80·22	Leaves	Fresh............................	—
3231	—	—	P	7·31	4·96	4·09	0·87	—	,,	Stems	—	—
3232	—	—	P	7·20	8·59	7·93	0·66	—	—	Roots	—	—
3233	15/5/45	6.50 a.m.	P	3·89	5·17	4·03	1·14	—	78·95	Leaves	Covered with frost, drooping......	—
3234	—	—	P	2·45	5·48	5·08	0·40	—	,,	Stems	—	—
3235	—	—	P	8·17	7·71	6·55	1·16	—	—	Roots	—	—
3236	15/5/45	12.04 p.m.	P	3·88	7·64	3·26	4·36	—	75·39	Leaves	Drooping.........................	—
3237	—	—	P	4·26	10·93	5·63	5·30	—	,,	Stems	—	—
3238	—	—	P	5·36	13·18	8·70	5·48	—	—	Roots	—	—
3239	15/5/45	8 p.m.	P	1·93	4·77	2·20	2·57	—	77·48	Leaves	Leaves drooping slightly...........	—
3240	—	—	P	4·82	8·62	3·80	4·82	—	,,	Stems	—	—
3241	—	—	P	12·00	13·79	9·90	4·89	—	—	Roots	—	—
3242	29/5/45	7 a.m.	P	2·16	3·07	1·09	1·98	—	70·58	Leaves	Taken out with roots; covered with frost	—
3243	—	—	P	2·47	6·15	2·53	3·62	—	,,	Stems	—	—
3244	—	—	P	11·50	9·20	6·20	3·00	—	—	Roots	—	—
3245	29/5/45	12.15 p.m.	P	2·47	3·60	1·48	2·12	—	62·28	Leaves	Drooping badly..................	—
3246	—	—	P	2·38	11·21	7·54	3·67	—	,,	Stems	—	—
3247	—	—	P	8·52	9·19	6·06	3·13	—	—	Roots	—	—
3248	29/5/45	7.45 p.m.	P	2·47	3·55	1·45	2·10	—	73·80	Leaves	Drooping badly..................	—
3249	—	—	P	2·29	5·44	2·40	3·24	—	,,	Stems	—	—
3250	—	—	P	12·58	10·81	6·22	4·59	—	—	Roots	—	—
3251	30/5/45	12.15 a.m.	P	3·83	4·34	1·48	2·86	—	71·87	Leaves	Drooping badly..................	1·00
3252	—	—	P	3·51	5·80	2·54	3·26	—	,,	Stems	—	1·33
3253	—	—	P	9·81	11·05	7·43	3·62	—	—	Roots	—	10·00
3254	30/5/45	7 a.m.	P	2·87	3·29	1·31	1·98	—	71·50	Leaves	Badly wilted, some plants lying flat after heavy frost	—

TABLE 8 (*continued*).

Lucerne Cut After Frost.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter. Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fibre.	Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
3255	—	—	P	2·28	5·48	2·32	3·16	—	,,	Stems	—	—
3256	—	—	P	12·79	9·10	7·44	1·66	—	—	Roots	—	—
3257	30/5/45	12.30 p.m.	P	2·26	3·44	2·32	1·12	—	64·80	Leaves	Badly wilted, most plants lying flat	—
3258	—	—	P	2·64	3·68	2·69	0·99	—	,,	Stems	—	—
3259	—	—	P	11·34	10·06	7·32	2·74	—	—	Roots	—	—
3262*	18/6/45	6.50 a.m.	P	1·79	3·31	2·18	1·13	—	69·90	Leaves	Drooping, some brown leaves present	—
3263	—	—	P	1·99	4·11	2·80	1·31	—	,,	Stems	—	—
3264	—	—	P	9·45	6·27	4·89	1·38	—	—	Roots	—	—
3265	18/6/45	12.20 p.m.	P	2·91	4·25	2·41	1·84	—	67·10	Leaves	Leaves and stems drooping slightly	—
3266	—	—	P	1·59	5·65	2·75	2·90	—	,,	Stems	Tops eaten off....................	—
3267	—	—	P	7·05	7·10	5·57	1·53	—	—	Roots	—	—
3268	18/6/45	7.30 p.m.	P	2·14	3·35	1·87	1·48	—	72·00	Leaves	Leaves and stems drooping slightly	—
3269	—	—	P	1·92	4·55	2·07	2·48	—	,,	Stems	—	—
3270	—	—	P	5·33	8·64	6·14	2·50	—	—	Roots	—	—
3271	19/6/45	12.15 a.m.	P	3·12	3·30	2·24	1·06	—	68·80	Leaves	Lucerne in poor condition..........	1·00
3272	—	—	P	1·06	5·05	3·32	1·73	—	,,	Stems	—	2·50
3273	—	—	P	7·87	8·10	5·83	2·27	—	—	Roots	—	22·50
3274	19/6/45	7.00 a.m.	P	1·68	2·79	1·92	0·87	—	65·00	Leaves	Leaves drooping..................	—
3275	—	—	P	1·06	5·12	3·20	1·92	—	,,	Stems	—	—
3276	—	—	P	11·27	9·02	7·02	2·00	—	—	Roots	—	—
3277	19/6/45	12.15 p.m.	P	2·59	2·67	1·76	0·89	—	66·60	Leaves	Leaves drooping; some brown leaves present	—
3278	—	—	P	1·68	5·20	3·27	1·93	—	,,	Stems	—	—
3279	—	—	P	10·59	8·12	7·96	0·18	—	—	Roots	—	—
3280	19/6/45	7.45 p.m.	P	1·06	3·20	2·36	0·84	—	63·90	Leaves	Green leaves fresh; but brown leaves in small quantity present	—
3281	—	—	P	2·34	4·29	2·65	1·64	—	,,	Stems	—	—
3282	—	—	P	9·38	8·66	6·57	2·09	—	—	Roots	—	—
3283	20/6/45	12.10 a.m.	P	2·84	2·47	1·15	1·32	—	70·30	Leaves	Condition same as 7.45 p.m., 19/6/45	—
3284	—	—	P	0·52	4·40	1·97	2·43	—	,,	Stems	—	—
3285	—	—	P	13·00	8·10	3·98	4·22	—	—	Roots	—	—
3286	20/6/45	7.10 a.m.	P	2·33	3·10	1·43	1·67	—	69·10	Leaves	Leaves drooping..................	—
3287	—	—	P	2·20	4·87	2·24	2·63	—	,,	Stems	—	—
3288	—	—	P	13·10	4·83	3·65	1·18	—	—	Roots	—	—

* Locality: Plot, Reserve.

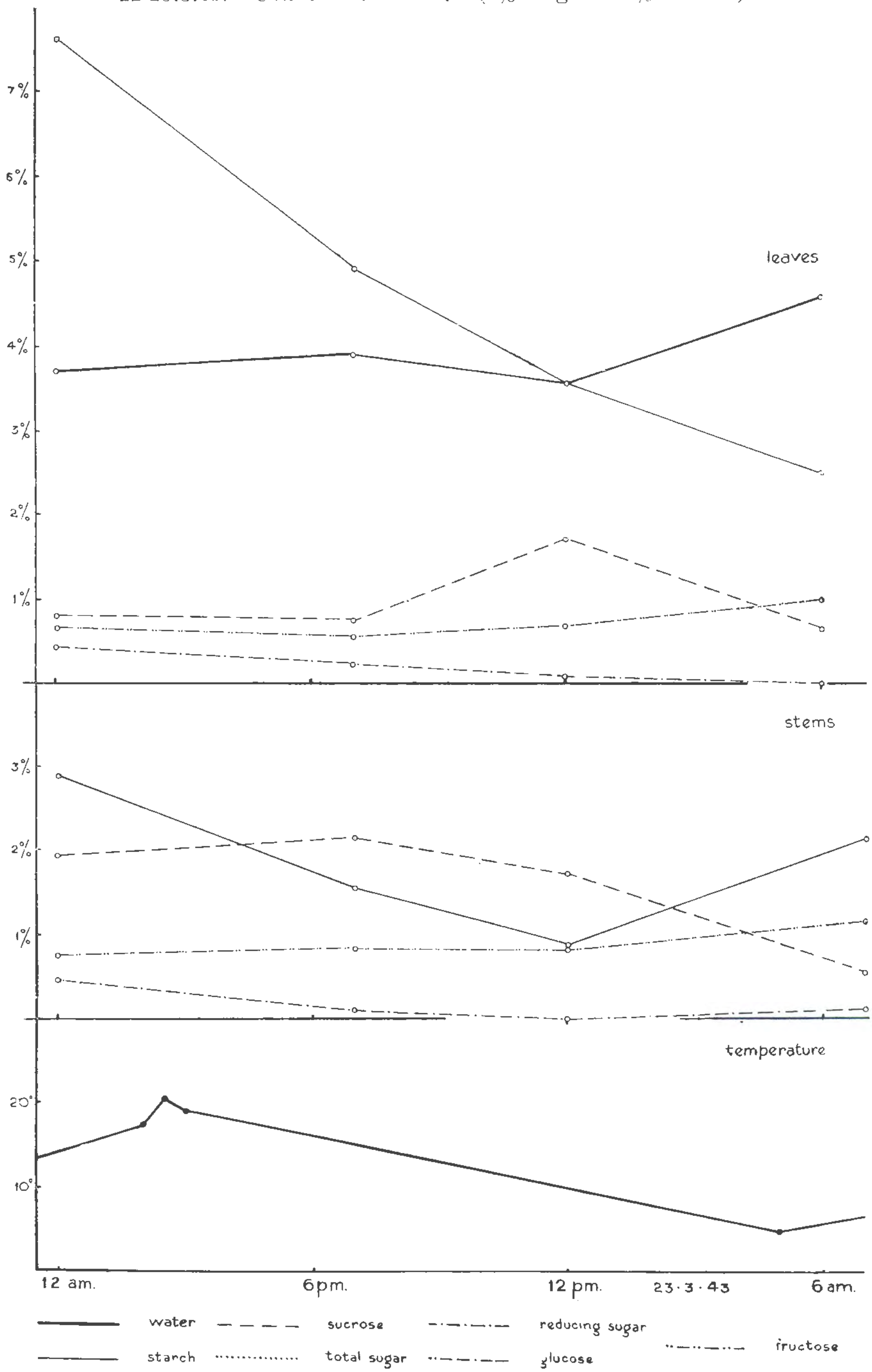
TABLE 9.

Progressive Wilting.

No.	Date.	Time.	Variety.	In Percentage of Dry Matter.					Water content in percentage of fresh mat.	Organ.	Remarks.	Ratio of leaves to stems.
				Starch.	Total sugars.	Reducing sugars.	Sucrose.	Fibre.				
2950	28/9/44	2 p.m.	P	1·81	3·43	3·00	0·43	20·88	72·34	Leaves	Just starts to wilt................	—
2951	—	2 p.m.	P	1·49	3·61	1·30	2·32	27·60	—	Stems	,, ,, ,, ...	—
2952	29/9/44	2 p.m.	P	1·67	3·19	2·43	0·76	—	71·02	Leaves	Rather wilted....................	—
2953	—	2 p.m.	P	0·53	3·49	2·26	1·80	—	—	Stems	,, ,, ...	—
2954	30/9/44	2 p.m.	P	1·09	2·52	2·14	0·38	—	70·11	Leaves	,, ,, ...	—
2955	—	2 p.m.	P	1·22	3·10	1·58	1·52	—	—	Stems	,, ,, ...	—
2956	1/10/44	2 p.m.	P	0·89	2·19	1·80	0·39	—	66·37	Leaves	Slightly wilted....................	—
2957	—	2 p.m.	P	1·15	2·47	2·14	0·33	—	—	Stems	,, ,, ...	—
2958	2/10/44	2 p.m.	P	0·35	1·73	1·61	0·12	—	63·51	Leaves	,, ,, ...	1:0·95
2959	—	2 p.m.	P	2·14	2·63	2·10	0·53	—	—	Stems	,, ,, ...	—
2960	3/10/44	2 p.m.	P	0·22	1·62	0·79	0·83	—	61·72	Leaves	,, ,, ...	—
2961	—	2 p.m.	P	1·20	2·18	1·80	0·38	—	—	Stems	,, ,, ...	—
2962	4/10/44	2 p.m.	P	0·50	1·72	1·47	0·25	—	63·26	Leaves	,, ,, ...	—
2963	—	2 p.m.	P	1·16	2·67	0·77	1·90	—	—	Stems	,, ,, ...	—
2968	5/10/44	2 p.m.	P	0·79	2·19	0·98	1·21	—	58·19	Leaves	Badly wilted.....................	1:1·00
2969	—	2 p.m.	P	1·20	2·54	1·74	0·80	—	—	Stems	,, ,, ...	—
2970	6/10/44	2 p.m.	P	0·83	1·80	0·83	0·97	17·26	61·23	Leaves	,, ,, ...	—
2971	—	2 p.m.	P	1·01	3·00	0·88	2·12	32·50	—	Stems	,, ,, ...	—
2972	7/10/44	12 a.m.	P	1·26	1·61	1·29	0·32	—	56·31	Leaves	,, ,, ...	—
2973	—	12 a.m.	P	1·43	2·75	0·95	1·80	—	—	Stems	,, ,, ...	—
2974	9/10/44	2 p.m.	P	2·02	1·57	0·60	0·97	—	57·16	Leaves	Slightly wilted....................	1:0·92
2975	—	2 p.m.	P	1·44	2·58	0·66	1·92	—	—	Stems	,, ,, ...	—
2976	11/10/44	2 p.m.	P	1·38	1·92	0·60	1·32	—	54·87	Leaves	,, ,, ...	—
2977	—	2 p.m.	P	1·16	2·76	0·60	2·16	—	—	Stems	,, ,, ...	—
2982	12/10/44	2 p.m.	P	0·89	1·62	0·52	1·10	—	56·66	Leaves	Wilting stronger..................	—
2983	—	2 p.m.	P	0·57	2·31	0·61	1·70	—	—	Stems	,, ,, ...	—
2984	13/10/44	2.15 p.m.	P	0·84	3·17	0·70	2·47	—	54·66	Leaves	Badly wilted.....................	—
2985	—	2.15 p.m.	P	0·89	1·95	0·57	1·38	—	—	Stems	,, ,, ...	—
2990	14/10/44	2 p.m.	P	2·67	1·48	0·47	1·01	—	56·26	Leaves	,, ,, ...	—
2991	—	2 p.m.	P	2·09	2·61	0·69	1·92	—	—	Stems	,, ,, ...	—
2992	16/10/44	2 p.m.	P	2·19	1·53	0·47	1·06	22·82	44·70	Leaves	Badly wilted, nearly dry...........	—
2993	—	2 p.m.	P	1·57	2·26	0·55	1·71	34·04	—	Stems	,, ,, ,, ,, ...	—
2964	4/10/44	2 p.m.	H	1·13	2·27	0·91	1·35	17·88	65·52	Leaves	Slightly wilted....................	—
2965	—	2 p.m.	H	0·80	3·42	1·10	2·32	39·51	—	Stems	,, ,, ...	—
2966	4/10/44	2 p.m.	H	0·00	3·10	1·20	2·00	19·01	55·20	Leaves	Badly wilted.....................	—
2967	—	2 p.m.	H	1·08	4·21	1·58	2·63	33·64	—	Stems	,, ,, ...	—
2978	11/10/44	2 p.m.	H	1·60	2·27	0·60	1·67	—	56·21	Leaves	Wilted, margin of plot better than 2980	1:1·00
2979	—	2 p.m.	H	2·02	3·44	0·66	2·78	—	—	Stems	,, ,, ,, ,,	—
2980	11/10/44	2 p.m.	H	1·16	1·34	0·48	0·86	—	30·21	Leaves	Badly wilted, middle of plot.......	—
2981	—	2 p.m.	H	0·66	1·86	0·40	1·46	—	—	Stems	,, ,, ,, ...	—
2986	13/10/44	2 p.m.	H	0·57	1·23	0·60	0·63	—	35·38	Leaves	,, ,, ,, ...	—
2987	—	2 p.m.	H	1·28	1·73	0·57	1·16	—	—	Stems	,, ,, ,, ...	—
2988	13/10/44	2 p.m.	H	1·18	1·66	0·49	1·17	20·86	52·94	Leaves	Drooping, better than 2986/87. Margin of plot	—
2989	—	2 p.m.	H	1·75	3·12	0·69	2·43	38·64	—	Stems	,, ,, ,, ,,	—

GRAPH 1.*

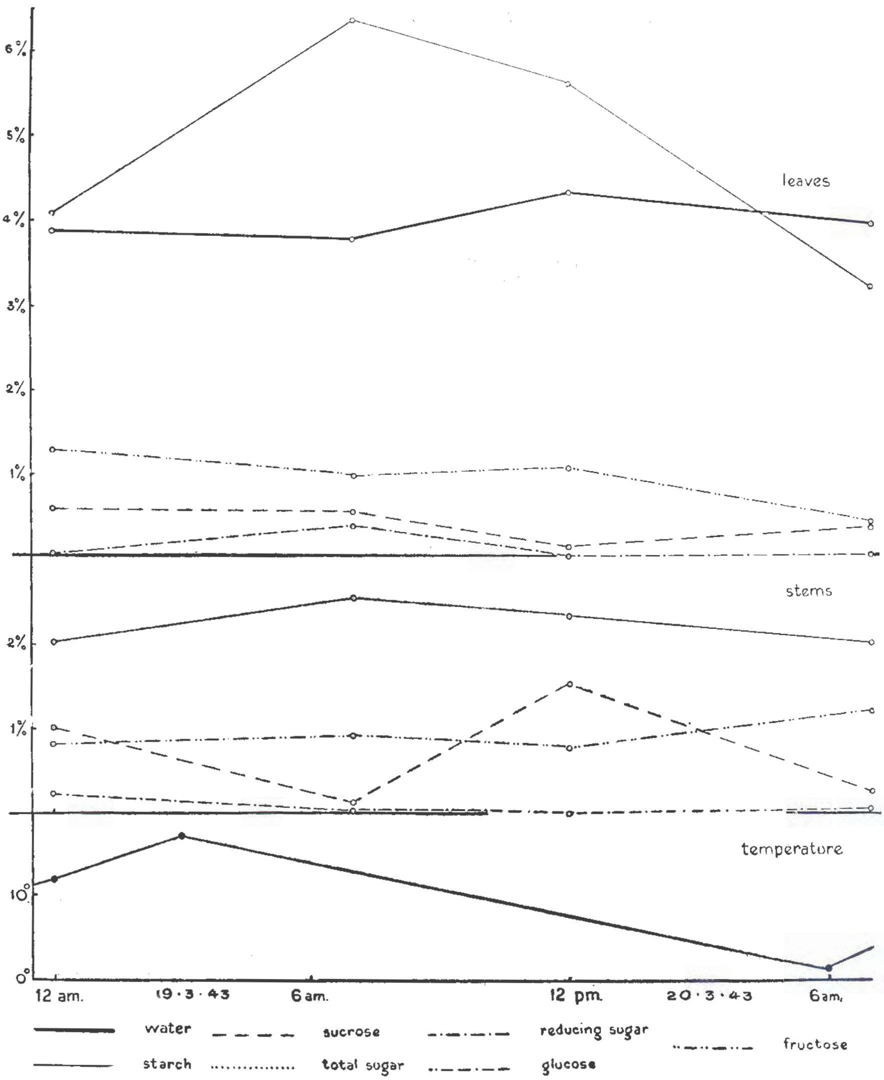
Leaves and stems of Provence lucerne, samples Nos. 2442-2453 (plot plant). *Date:* 22-23.3.43. *Condition:* Fresh. (1% sugar=20% water.)



* In Graphs 1-12 time and date are plotted on abscissa and percentages of sugar, starch and water on ordinate.

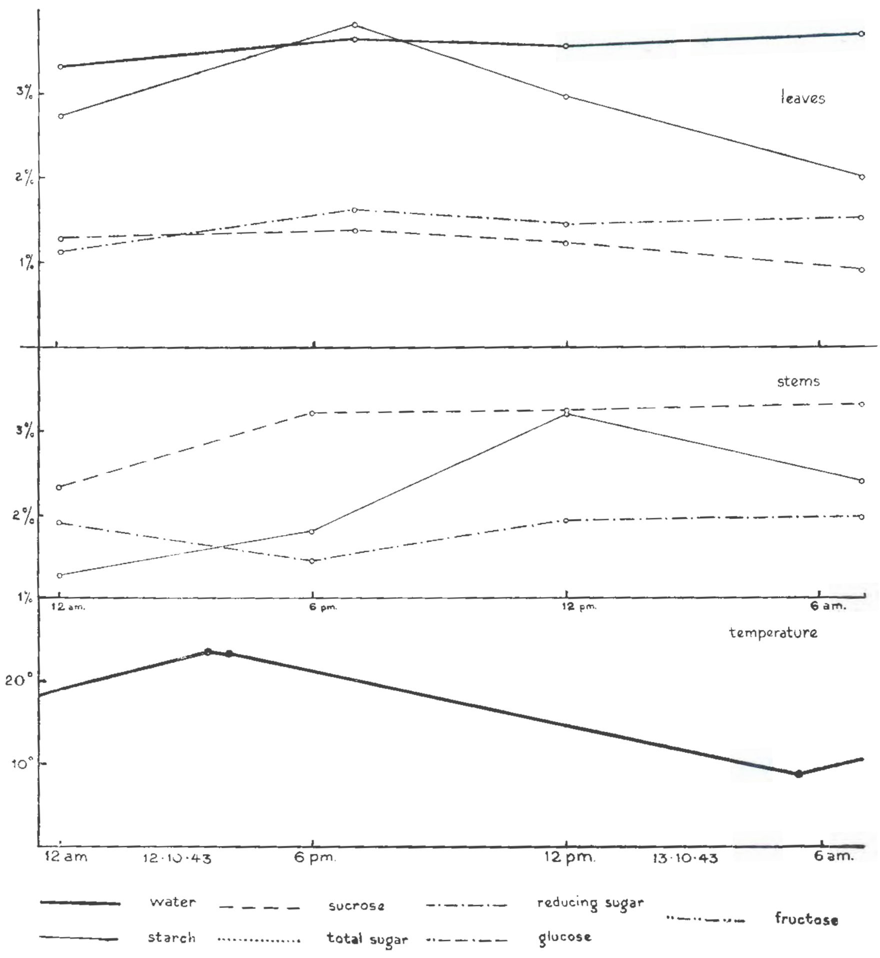
GRAPH 2.

Leaves and stems of Hunters River lucerne, samples Nos. 2433-2441. *Date:* 19-20.3.43. *Condition:* Fresh, about 1 ft. high. (1% sugar=20% water.)



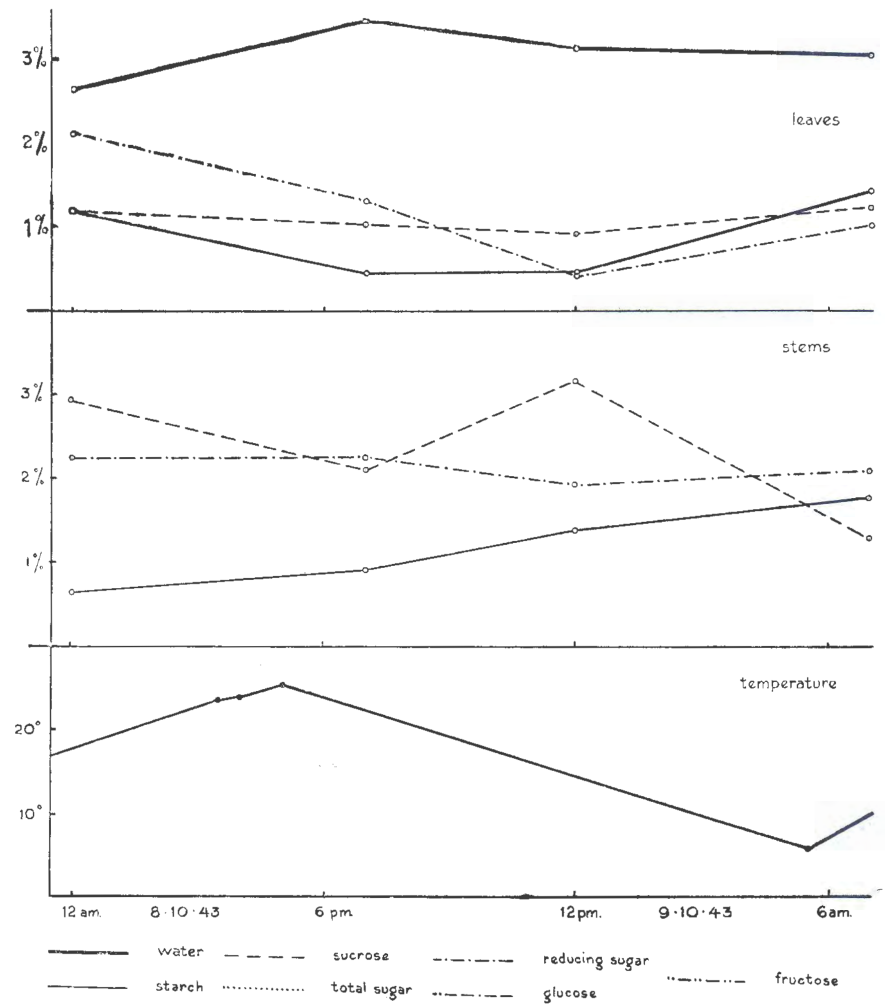
GRAPH 3.

Leaves and stems of Provence lucerne, samples Nos. 2588-2595 (plot plant). *Date:* 12-13.10.43. *Condition:* Wilted. (1% sugar=20% water.)



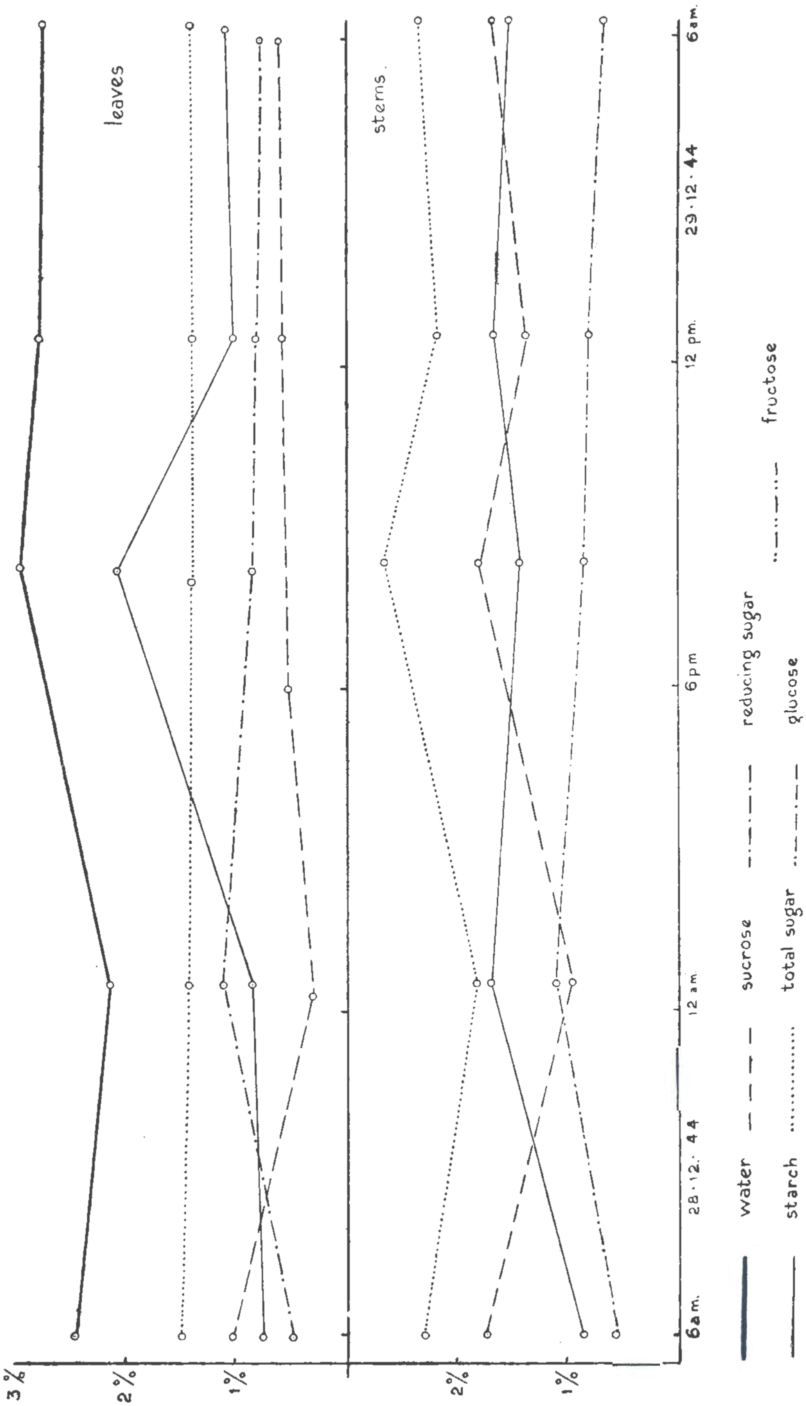
GRAPH 4.

Leaves and stems of Hunters River lucerne, samples Nos. 2604-2611 (plot plant). *Date:* 8-9.12.43. *Condition:* Permanently wilted. (1% sugar=20% water.)



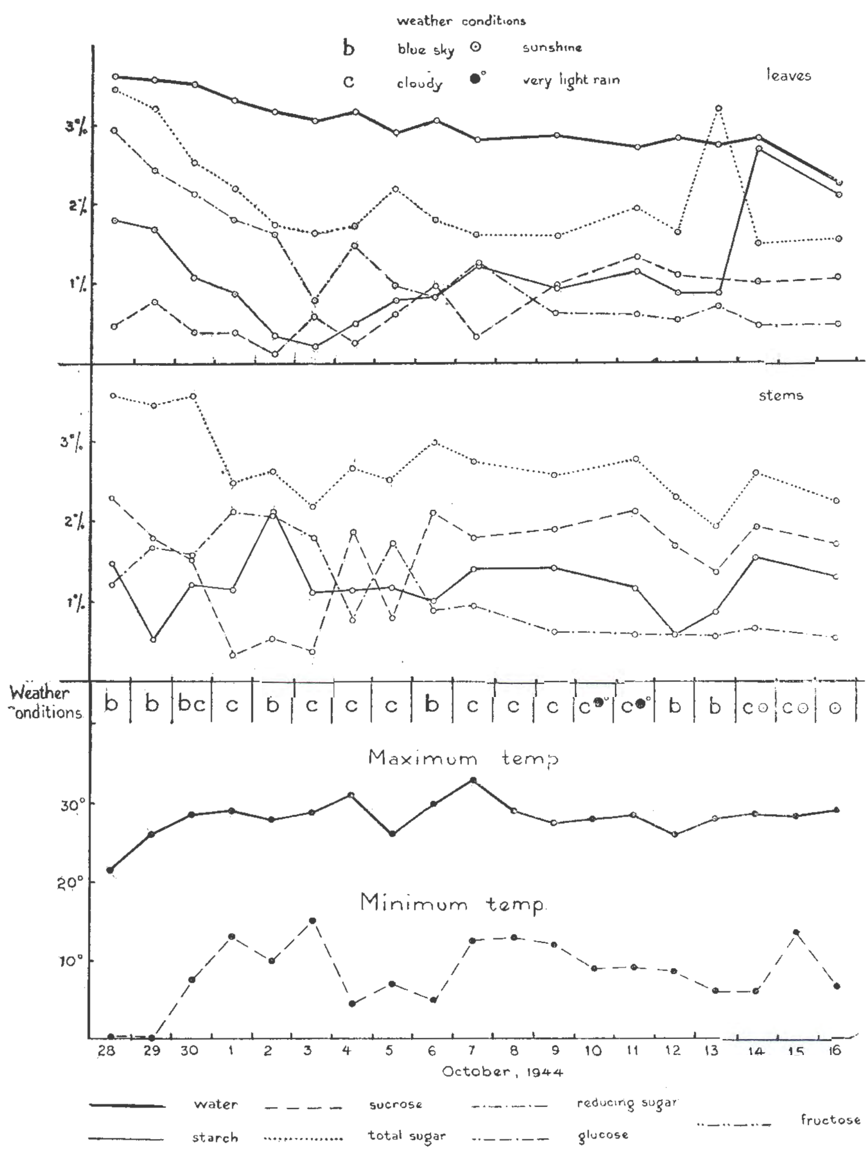
GRAPH 5.

Leaves and stems of Provence lucerne, samples Nos. 3053-3102 (plot plant). *Date:* 28-29.12.44. *Condition:* Permanently wilted. (1% sugar=20% water.)



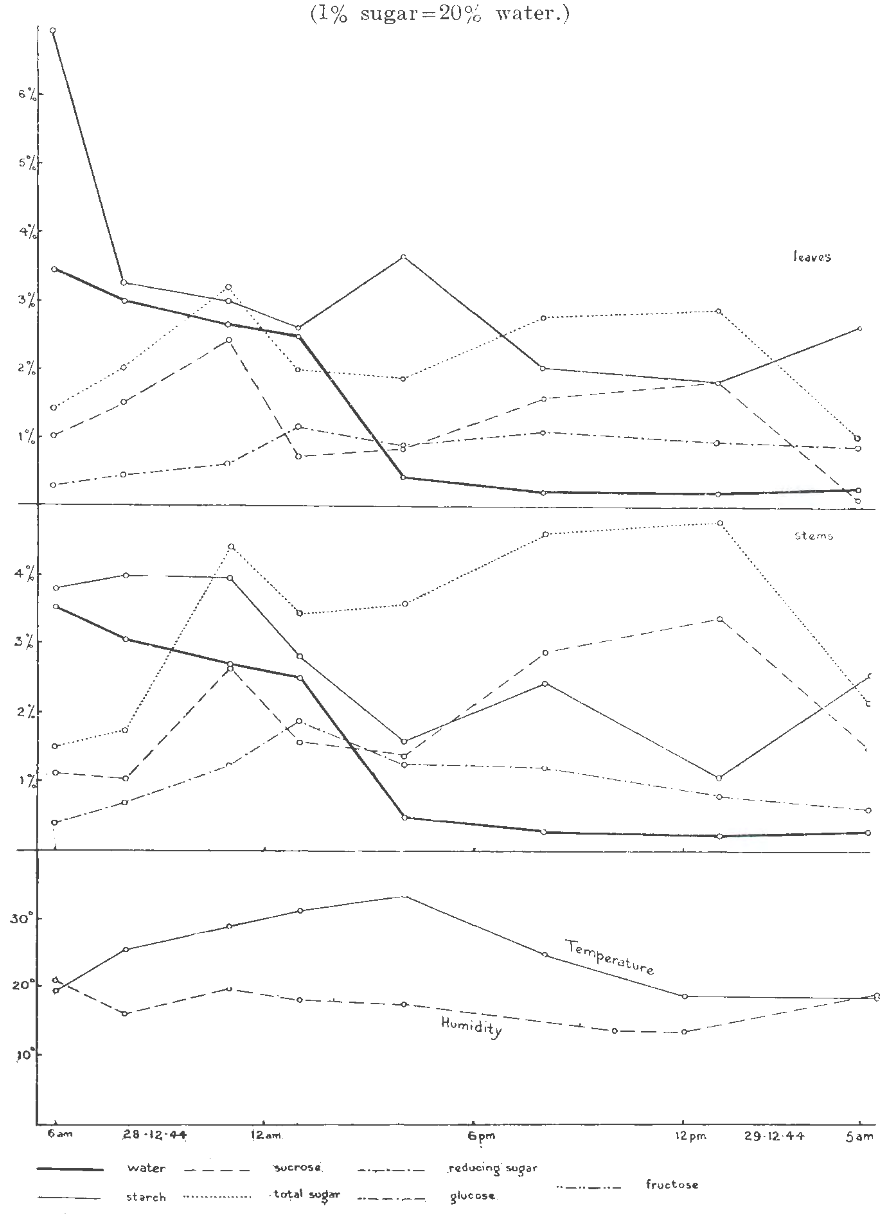
GRAPH 6.

Leaves and stems of Provence lucerne, samples Nos. 2950-2993 (plot plant). *Date:* 28.9.44-16.10.44. Taken between 12 a.m. and 2 p.m. *Condition:* Progressive wilting. (1% sugar=20% water.)



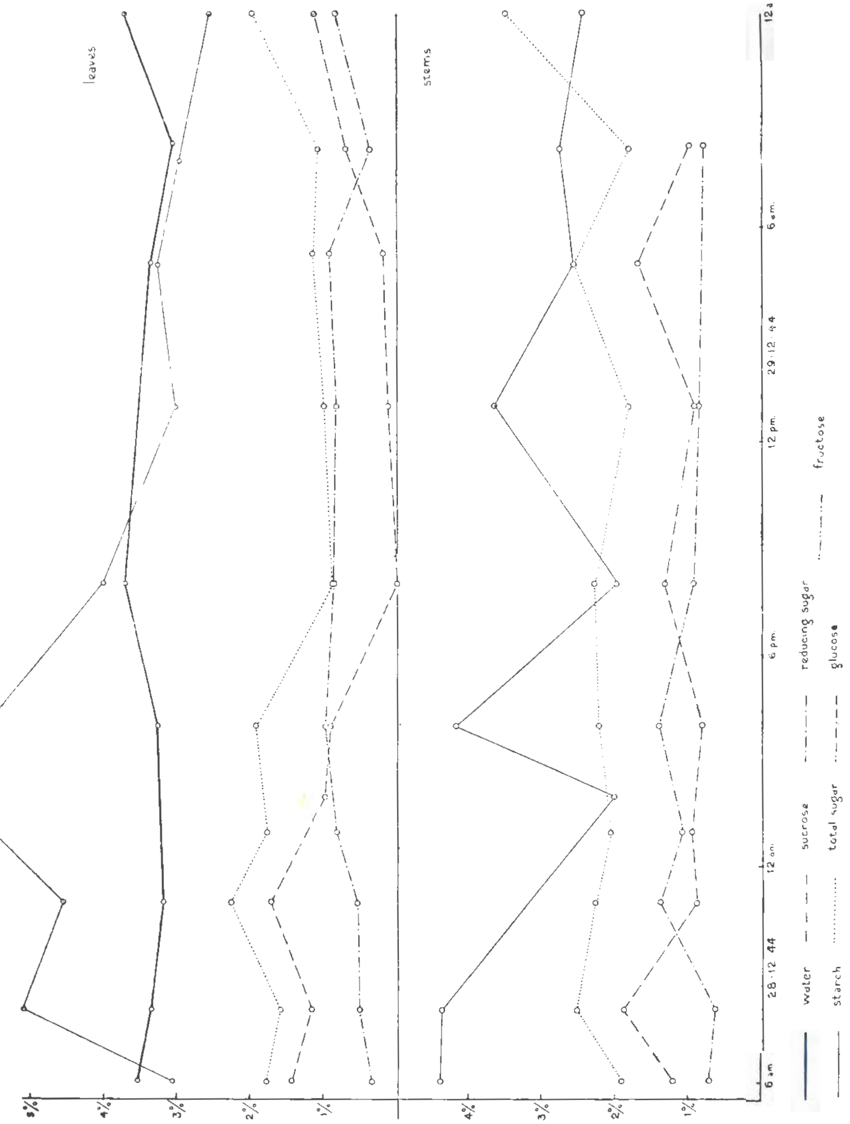
GRAPH 7.

Leaves and stems of Provence lucerne, samples Nos. 3057-3096 (plot plant). *Date:* 28-29.12.44. *Condition:* Leaves allowed to wilt in the sun, stems left to dry in the sun. (1% sugar=20% water.)



GRAPH 8.

Leaves and stems of Provence lucerne, samples Nos. 3065-3106 (plot plant). *Date:* 28-29.12.44. *Condition:* Cut and put with stems in water. (1% sugar=20% water.)

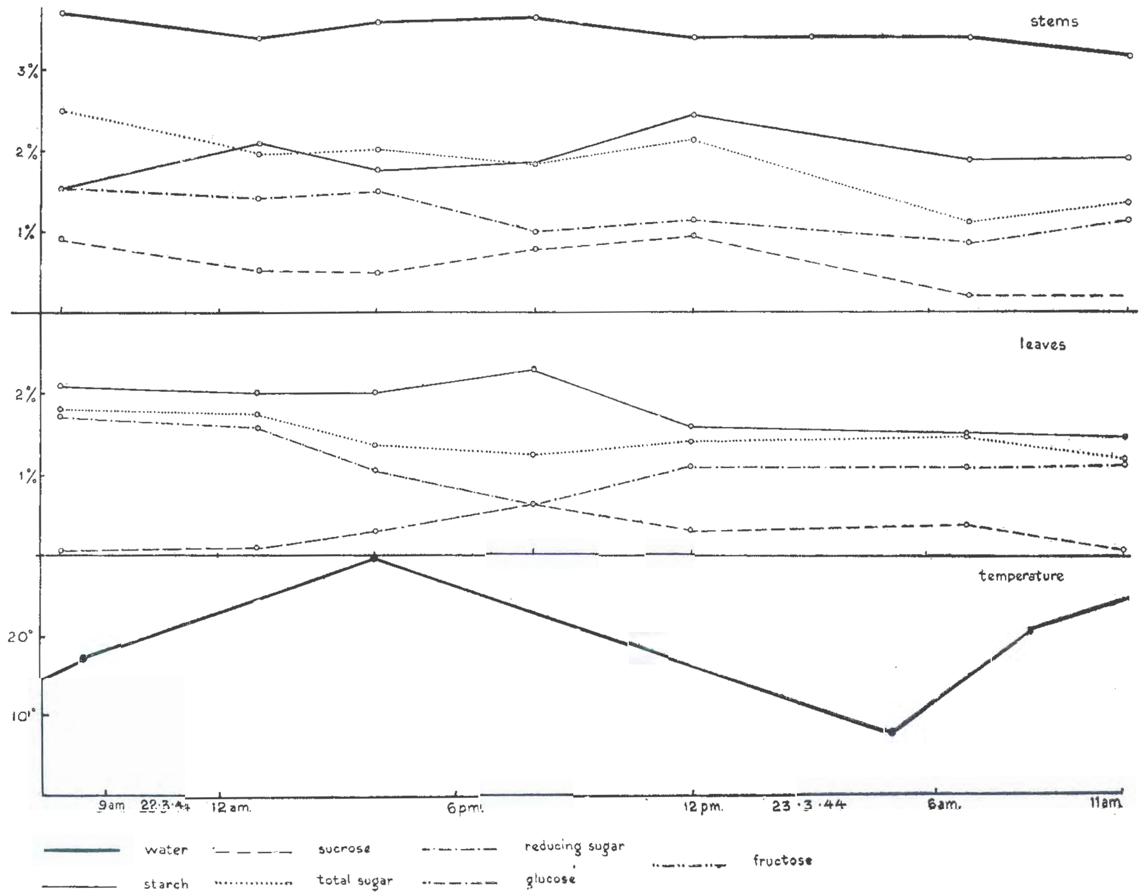


GRAPH 9.

Leaves and stems of Hunters River lucerne, samples Nos. 2744-2761 (plot plant). *Date:* 20-21.3.44. *Condition:* Cut and allowed to dry in sun. (1% sugar=20% water.)

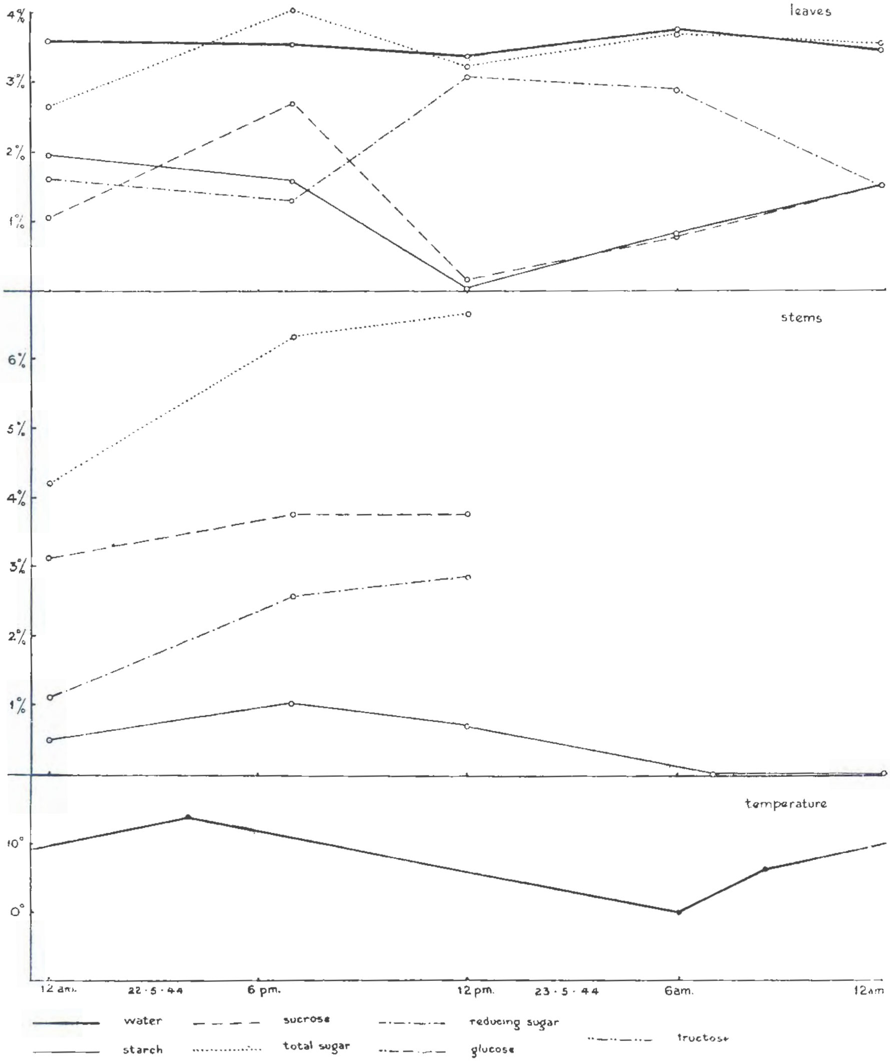
GRAPH 10.

Leaves and stems of Provence lucerne, samples Nos. 2776-2789 (plot plant). *Date:* 22-23.3.44. *Condition:* Cut fresh and exposed to sun in water. (1% sugar=20% water.)



GRAPH 11.

Leaves and stems of Provence lucerne, samples Nos. 2852-2861 (plot plant). *Date:* 22.23.5.44. *Condition:* Cut after first frost. (1% sugar = 20% water.)



GRAPH 12.

Leaves and stems of Hunters River lucerne, samples Nos. 3004-3013 (plant). *Date:* 23-24.8.44. *Condition:* Cut after late frost. (1% sugar=20% water.)