# Physiological Plant Studies in South Africa.

## PART II.—TRANSPIRATION OF GRASSES AND OTHER PLANTS UNDER ARID CONDITIONS.

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IN the preceding paper upon "Grass Wilting," of which the present article is to be regarded as Part II, it was explained that the grasses in Armoedsvlakte (Vryburg, Bechuanaland) wilt at a time when other plants remain fresh, that they show no morphological adaptations to drought, that their suction force is not adapted to meet temporary drying of the soil, and that their osmotic values fluctuate widely with varying conditions of transpiration. The present communication deals with the protocols acquired in transpiration experiments under various conditions.

### METHODS.

In investigating transpiration three methods were used:—(1) Direct weighing of the plants at hourly intervals, (2) automatic weighing by the Richard self-registering Balance, (3) determination of relative water-loss with cobalt chloride papers, by one of the Livingston modifications (1912).

(1) In the *direct weighing method* the plants were transferred to small glass bottles with wide mouths, which were closed with rubber-sheeting as soon as good rooting had established itself in the soil. The opening for the plant was sealed with paraffin wax, and the neck of the bottle bound with insulating tape so that the rubber-sheeting could be easily fixed with paraffined twine. This is the method used by Senn (1922), except that fresh rubber-sheeting was fixed on shortly before taking experimental observations, since in the climate of Armoedsvlakte rubber perishes quickly. In affixing the rubber a wide glass tube pointed at one end was used, the leaves being gathered into the wide end and the sheeting worked from the narrow end down over the plant. In general, considerable difficulty was experienced in getting the grasses to grow in bottles, or even in flower-pots, and for plants with big roots the method had to be abandoned in favour of the cobalt chloride process.

Once the plants were well established the glass bottles were weighed hourly throughout the day-time, or throughout the whole twenty-four hours. In studying the behaviour of grasses under varying conditions of soil moisture, the pots were watered regularly until the plants were well developed and had formed new roots. Some were then left without water and others watered at will. To provide sufficient water for development it was necessary to take fair-sized bottles containing 300-500 gm. of soil. Under these conditions the light grass plant could still call upon an amount of water fifteen to thirty times its own weight, even if the soil moisture were allowed to fall to 1 or 2 per cent. Smaller bottles (50 gm.) were at first tried, but with them lack of water-reserve affected the results. Throughout the experiments the bottles were exposed to natural meteorological conditions by burying in the soil so that only the leaves were exposed. The temperature and relative humidity of the atmosphere were determined every hour with an Assmann psychrometer, and the soil temperature taken at a depth of 3 cm. In the earliest experiments the Assmann psychrometer was not available, and observations were then made with the ordinary dry bulb thermometers, which were swung to exclude the influence of insolation.

(2) In the *Richard balance method* (Burgerstein, p. 9) the glass bottle or pot prepared as above was placed upon the left pan and almost counterpoised with arbitrary weights. The usual procedure of fixing a wind-screen in a basin of water on the pot side of the balance was then tried, but this protection was insufficient for the strong winds prevailing at the time, and good self-registered curves were not obtained until the whole apparatus was enclosed in a large wooden box specially constructed for the purpose and mounted on wooden legs $3\frac{1}{2}$ feet from the ground. Plate I illustrates the apparatus. The top and front of the box could be readily opened for handling, and the lid was provided with an Iris diaphragm which could be opened widely for insertion of the pot on to the balance-pan. On partially closing the diaphragm the wind was effectively excluded from the balance within the box, without interfering with the free movement of the pan and plant. In this way good charts were obtained within the limitations of instrument itself. On the whole, the Richard balance does not appear to be very suitable for transpiration work on such light plants as grasses, since a loss of 5 gm. of water only corresponds to about one square on the chart. On very small plants in very small pots (50 gm. load) the transpiration is hardly recorded at all, in spite of the weight-regulating mechanism, and with large pots the sensitiveness leaves much to be desired. For plants which have a larger proportion of fresh active tissue than grasses, and correspondingly higher transpiration, the balance may do all that is required, but in the case of the grasses concerned in the present investigations the information obtained by the method was rather limited; nevertheless useful. There is, of course, no difference in principle between automatic weighing by the Richard balance and manual weighing at hourly intervals, but one point of difference in practical execution of the determinations must be mentioned. In the seven-day automatic records the pots remained in the interior of the box, and were therefore exposed to lower temperature than in the diurnal weighing records where the pots were embedded in the sun-heated soil. On the other hand, the white painted box reflected radiant energy, and therefore exposed the leaves to somewhat higher temperature.

(3) In the *cobalt chloride method* for determining *relative* transpiration (Livingston, 1912 and 1913, Livingston and Shreve, 1916) filter-paper was soaked for fifteen minutes in a 3 per cent. solution of cobalt chloride, hung up until air-dry, and finally dried in a desiccator. A small square of the blue test-paper from the desiccator was then clipped in contact with the leaf under investigation, and the time required to restore to pink noted with a stop-watch. The

standard time for effecting the same colour change was determined by placing a piece of wet blotting-paper (saturated and drained) on a glass slide, covering this with an ebonite plate of the same size and 1 mm. thick, but with a central hole of about 1 sq. cm. area; placing a suitable piece of cobalt paper over this, covering with a second glass slide, and noting the period required to effect the change to pink. In each case a standard "control time" was determined side by side with the "estimation time" on the leaf, in order to reduce to a minimum the variations due to variable wind. Relative data were then obtained by dividing the standard time in the saturated atmosphere above the wet blotting-paper by the observed time of change on the leaf. Since this method was first introduced into the literature (Livingston, 1913, 1914, and Livingston and Shreve, 1916) several improvements have been recommended. Livingston and Shreve (1916) now advise a porous atmometer instead of blotting-paper, and sharper detection of initial and end points by use of different coloured papers. An atmometer was not available at the time of the Bechuanaland work, and attempts at improvising colour standards were not very successful. Whatman No. 1 paper had to be used in place of the Munktel Swedish 00 recommended by Livingston and this seemed to give a somewhat too dark initial tint and somewhat too white final tint. Nevertheless the method gave satisfactory results, very useful for the purpose in view; and having once commenced with the original simple method, it was considered sufficient to retain it throughout the series of investigations.

*Wilting Experiments.*—In many of the transpiration experiments, wilting and recovery of the grass plants was observed with change of weather. A series of experiments of considerable duration was therefore undertaken, to ascertain whether the grass wilted "temporarily" at one degree of soil moisture and "permanently" at another (Briggs and Shantz, 1912; Blackman, 1914; Livingston, 1917, and their cited literature). The same experiments were designed to show whether the transpiration decreases proportionately with the soil moisture and whether a decrease of transpiration occurs at wilting.

The method used for these observations was the manual weighing of pots at regular intervals. The experiments lasted from a few days to a few weeks, the rubber sheeting being renewed about twice a week to ensure tight joints. In absence of rain the pots were kept in the soil in the open, but safeguarded from showers by transferring to a veranda when necessary. A heavy rain allowed the plants to recover in spite of the rubber insulation. It may be added that all three initial experiments were carried out in the rainy season, and that in extreme drought the observations would have been completed in from one to four days. The rainy season, however, is interspersed with long periods of cloudless days, so that the transpiration was not at all affected by lack of light. During very dry days the pots were weighed twice daily, before sunrise and after sunset; but under ordinary conditions only before sunrise. When the first sign of wilting occurred, a sample of the soil was taken to determine moisture-content; and the plant then placed under a bell jar in a moist atmosphere for twenty-four hours At the end of this time its condition was carefully noted. If it recovered it was again exposed to the sun (in the sealed pot) and weighed. In a short time it again wilted, and this second wilting was generally permanent, i.e. the plant did not recover when again transferred to a saturated atmosphere. Occasionally, however, the plant recovered a second time and was then left in the sun until its final withering (Livingston, 1917).

*Determination of Transpiration Units.*—After all weighings were concluded, whether in the daily weighing experiments, the Richard balance records, or the wilting observations, the fresh matter and the surface of the leaf were estimated. Only one side of the leaf surface was considered, and the determination made by weighing equivalent-sized papers. In addition to this, the total mass of the roots and the proportion of absorptive roots were estimated, and a coefficient calculated by dividing the weight of the aerial parts of the plant by the weight of the absorbing roots.

*Determination of External Factors.*—For the twenty-four hour experiments, hourly readings of air and soil temperature, and of atmospheric humidity, were taken. Wind and clouds were observed. At the end of each experiment the soil moisture was determined. In the observations with the Richard balance, the same readings were taken at longer intervals, but soil temperature was naturally disregarded. In the determination of relative transpiration similar data were recorded at suitable intervals. In the wilting experiments, the meteorological data of the laboratory were used.

*Season of Observations.*—The twenty-four hour experiments were carried through the whole year 1923-24, with the exception of December, 1923, and the periods when no grass was available. The records from the Richard balance were obtained between June, 1923, and May, 1924; from the wilting experiments in March, 1924, and from September to December, 1924. Determinations of relative transpiration were made at irregular intervals from 1923 to the beginning of 1925.

## Results.

Various selected protocols are given in the form of tables and charts in the appendix, and reference to these in the course of reading the text will render the following discussion sufficient. As an example of a whole experiment, the complete records of Experiment 39 are added in Tables 5 and 6.

*Daily Variation.*—The direct weighing records (table 6) show the general daily course of transpiration, which is much the same as that observed in Europe so long as the grasses are not subjected to the extreme drought periods of summer. The rise and fall is generally steeper than under European conditions. When measured on bright days during the rainy periods of summer a regular increase in transpiration occurs from morning to midday. At noon a relatively large fall occurs, followed by a rise to a maximum and a subsequent decrease until sunset. During the night some fluctuations occur, due partly to the stimulus of change from light to darkness, and partly to the change in relative humidity. The fall at noon corresponds to the " incipient drying " of American authors (Livingston and Brown, 1912; Shreve, 1913).

Even on cloudy days the loss of constitution-water of the grass reaches 2 to 3 per cent. On clear days it may go as high as 20 per cent. without visible wilting, although some leaves then show folding (*Cymbopogon plurinodis* and *Themeda*).

In autumn (April to June) the transpiration is not so regular as in summer. The autumn of 1923 was dry and fluctuations frequently occurred even in the forenoon. The observations of spring, 1923, and the ensuing summer (October, 1923 to January, 1924), fall partly in a time of extreme drought and very high temperature; partly on clear days in the rainy period of November, when it rained about every eighth day with cloudless sky between. The daily changes in transpiration are then somewhat different to those of the first half of 1923, and the decrease does not only occur at noon, but often as early as 10 a.m. A further rise generally follows, but there may be one or more downward fluctuations in the early afternoon. Occasionally, but rarely, the absolute maximum is reached in the forenoon, a happening never observed in the early part of 1923. It will be noted that these variations from the usual occur especially in dry soil (*Eragrostis* 3 in table 6). On clear moonlight nights the transpiration of the grasses goes on, and even attains considerable dimensions. On dark nights and on frosty nights the grasses take up much water, which they part with again very easily during the first sunny hours of morning. Towards the end of 1923, however, and in January, 1924, the air was so dry during the night that practically no water absorbtion occurred.

*Annual Variation.*—From the available data of Table 1 a yearly variation may be noted in the grasses. Even when the fact is allowed for that the temperature at the beginning of 1923 was lower than at the end, the course of transpiration runs as follows:—High transpiration in spring-time, slowly decreasing after the November rains, but still high in December and January (summer), further decreasing through February and March, and rapidly falling in late autumn and early winter.

*Position of Maxima and Minima.*—In the early part of 1923 the maximum rate of transpiration occurs at noon, or in the early afternoon, at the period of strongest insolation but not of highest temperature (chart 4). Considering, however, the fact that leaf temperature is the resultant of both air warmth and direct insolation, it is improbable that the temperature was supra-optimal and more likely that the temperature of the leaf itself was really highest when the transpiration was greatest.

At the end of 1923 and in January, 1924, scattered maxima occur earlier in the day, especially with dry plants. In these cases it would appear that air-temperatures over 33° C., together with strong insolation, are supra-optimal. The minimum temperature for transpiration on clear nights is one degree below zero.

*Daily and Mean Hourly Values.*—The daily values for transpiration, i.e. the total transpiration during twenty-four hours, fluctuate very considerably in the grasses studied. They are especially large in the summer of 1923-24. The following figures represent the range per twenty-four hours per 1 gm. fresh matter:—

| | *Grams.* | |
|---|---|---|
| *Eragrostis superba* ... | 0.9–18.7 | |
| *Digitaria eriantha* ... | 3.0–21.0 | |
| *Themeda triandra* ... | 6.0–17.5 | |
| *Cymbopogon plurinodis* | 4.2– 6.2 | (January only.) |
| *Sporobolus fimbriatus* ... | 4.2–29.2 | |
| *Aristida uniplumis* ... | 7.2 | |
| *Cynodon dactylon* ... | 2.0–17.0 | |
| *Brachiaria Marlothii* ... | 6.3– 8.4 | |
| *Tragus racemosus* ... | 6.0–22.0 | |

The factor of soil moisture is not specifically taken into account in stating these figures, but all the very high values were obtained during a drought period. The data are therefore different to those recorded in a preliminary communication (Henrici, 1923, p. 362), in which observations of a better year were recorded. Broadly considered, the lowest values (Tables 1 and 2) are found in autumn and winter, and the highest values in the summer months—November, 1923, to January, 1924. The few exceptions will be discussed later. Transpiration depends primarily upon the mass of absorbing roots, and hence it is not surprising to find that, under the same meteorological conditions, plants with poor root development transpire only half as much water as plants with extensive roots. When the roots are uniformly well developed and the plants fresh, the extent of transpiration of different individuals of the same species over a lengthy period does not vary by more than 10 per cent. The hourly variation between individuals may be greater, but total amount transpired in twenty-four hours is much the same.

In order to facilitate comparison of the investigated grasses with other plants under other climatic conditions, transpiration is stated in Table 1 as hourly average per 100 sq. cm. of simple leaf surface. The values for each month are given separately, and in the last column a yearly average (of limited comparative value) is reckoned. Since it is impossible to consult the extensive original literature on transpiration at a distance of many thousand miles from Europe, comparison with Giltay's values may be offered (Burgerstein, 1904, p. 162). As an average value for all transpiration experiments with *Helianthus*, in the warm humid climate of Java, as well as in the climate of Holland, Giltay obtained 0.6 gm. per 100 sq. cm. of simple leaf surface. The values recorded in the present paper for grasses in summer time are, with few exceptions, higher than the values given by Giltay. Even the average yearly value, which includes the low winter figures, reaches 0.6 gm. in the majority of cases. This means that the transpiration power of the investigated grasses is great. The hourly maxima are also considerably higher than Giltay's values and therefore bring out the same points:—

*Maximum Hourly Transpiration. Gms. per 100 sq. cm. of Leaf Surface.*

| | Jan. 1923–Jan. 1924. | Jan.–July 1923. |
|---|---|---|
| *Eragrostis superba* ... | 0.65–4.9 | 0.67–2.1 |
| *Digitaria eriantha*... ... | 0.3 –4.7 | 0.9 –3 8 |
| *Themeda triandra* ... ... | 1.15–4.2 | 1.15–3.3 |
| *Sporobolus fimbriatus* ... | 0.8 –4.2 | — |
| *Cymbopogon plurinodis* | 1.4 –2.1 | — |
| *Aristida uniplumis* ... | 2.3 | — |
| *Cynodon dactylon* ... ... | 0.3 –3.9 | 0.3 –2.0 |
| *Brachiaria Marlothii* ... | 1.5 –2.3 | 1.5 –2.3 |
| *Tragus racemosus* ... ... | 1.03–3.4 | 1.03–3.4 |

The hourly maxima again fluctuate considerably, but again the low values occur in autumn and winter and the high values in the hot months, especially in October to December, 1923, a fact which explains the relative figures for the periods in the first and second columns above. It should be emphasized, however, that these values are only sample data obtained in the course of the general investigations, and that they are not to be regarded as invariable. The order of magnitude of the data is doubtless correct, however, since they were obtained from about forty experiments on about 200 plants. It may be added that on two occasions *Digitaria eriantha* varied from the general rule that the values for the end of 1923 were higher than in the beginning of the same year, but both exceptions can be readily explained since the two particular plants concerned dried out completely in experiment.

*Dependence of Transpiration upon Soil Moisture.*—The water-content of the soil influences the transpiration of the investigated grasses in various ways. Low moisture allows of only feeble development of the root system, and this fact was apparent both in the pot-cultures and in the plants growing naturally in the open veld. The already scanty water supply is therefore drawn upon only with the greatest difficulty. Furthermore, the total water at disposal of the plant is lower, and since the movement of moisture in the soil is slow the supply near the roots is soon exhausted. Finally, the stomata may close under the influence of the dry condition and the transpiration so diminish. If the root system is insufficiently developed to provide sufficient water for the leaves, the stomata should, theoretically at least, regulate the transpiration accordingly. These various points may be separately considered in regard to their influence upon water loss.

*Extent of Absorbing Roots.*—Small size of root system, particularly of the absorbing roots, is quite specific for these grasses of arid soils (*cf.* Huber, 1924, p. 20). The case is one in which no adaptation to edaphic conditions has occurred, and explains why it is that grasses do not prevail in South Africa in areas of very low rainfall (below 8 inches) and only appear when the average precipitation is favourable. The peculiar character of grass roots in Bechuanaland (*cf.* companion paper, Part I, "Wilting," p. 627) is doubtless due to a good development during the strictly seasonal period of rainfall, when the necessity for such development is lowest, followed by a shrinking and dying down during the drought periods when they are most needed. From the determination of the ratio between fresh matter of aerial parts and fresh matter of absorbing roots (as unity) in the present experiments, it is apparent that the smaller the coefficient the better does the plant transpire, that is, the lower the proportion of active aerial tissue to active root tissue the better do individual plants behave under identical conditions. Below the value 3, however, no further increase in the transpiration could be detected in grasses, so long as the soil was not excessively dry. Under equal conditions of soil moisture high coefficients cause a decrease in the amount of water transpired, although the drop is not directly proportional to the greater leaf tissue. The transpiration decreases more slowly than the coefficient increases, and it is especially noteworthy that the effective coefficient is very different for different plant families. As a unique example, *Mesembryanthemum Lesliei* may be mentioned; its transpiration actually remaining at a maximum with a coefficient of 500, that is, with its aerial tissue five hundred times as great as its active absorbing roots (compare Huber, 1924, pp. 20-29).

The reduced transpiration with a small root system is in itself an advantage from the point of view of water output to the grass, but from the point of view of absorption of salts from the soil there is little doubt that the smaller transpiration stream may involve the plant in deficiency of certain minerals. If the soil itself is notably poor in certain constituents, as is specifically the case for phosphorus on Armoedsvlakte, then the plant has still further to struggle with shortage of food constituents (*cf.* Theiler, Green, and Du Toit, "Phosphorus in the Live Stock Industry." *J. Dept. Agric.*, May, 1924).

It may be emphasized that the proportion of absorbing roots is sufficient to explain the extent of transpiration under most, but not all, conditions of temperature and light (Table 2). At a period of extreme drought certain observations on *Digitaria* showed a low transpiration in spite of a low coefficient. Quite early in the experiment concerned the leaves showed permanent wilting, and at the end were completely dry. The roots, however, remained in relatively good condition. In the veld itself this condition is probably quite common, and often on a hot day every green leaf of *Digitaria* may disappear, leaving only dry remains. As soon as the temperature falls and more moisture is secured, young leaves shoot up again, thus showing that the roots have not suffered seriously.

Under experimental conditions plants of *Eragrostis superba* were established with a good root system, and the soil then allowed to dry until the moisture fell to very low limits. At the end of the experiment only 0.1 to 0.3 per cent. of soil moisture remained, and yet the plants had not wilted. This condition could, of course, not last long, and wilting would probably have occurred a few hours later owing to almost complete abstraction of water. Nevertheless the observation is striking, since the plants transpired well and apparently possessed roots capable of exhausting the soil almost completely of water. It is interesting that this experiment was only successful with Eragrostis and not with several other grasses, a fact probably attributable to the peculiar development of detachable spongy tissue around the root of *Eragrostis* (*cf.* companion paper, Part I, "Wilting," p. 627). *Cymbopogon plurinodis*, in three determinations, did not show a transpiration influenced by the proportion of absorbing roots.

Although the "leaf-root coefficient" undoubtedly exercises a great influence upon the general extent of grass transpiration, it is improbable that it is the decisive factor in dry soil, except with plants such as *Eragrostis*. It would appear that in practice the actual amount of soil moisture becomes the limiting factor under drought conditions.

*Direct Influence of Soil Moisture* (Charts 1, 2, 3, 4, Table 2).—In specific investigation of this factor the surprising result was obtained that *only a few of the grasses were able to regulate their transpiration according to the degree of soil moisture.* (Compare Charts 1 and 3 and Table 2.) With a soil moisture decreasing from 20 per cent. to 2 per cent., diminishing transpiration generally occurs, although it may happen in a few cases that the water output is as high at the lower figures. If, in Table 2, grasses with approximately the same root coefficient, or grasses which show a high transpiration in relation to their root coefficient, are compared, it is seen that *Cynodon dactylon* is the only plant which regulates its transpiration really well according to soil moisture; and that of the characteristic perennial grasses, *Digitaria eriantha* is the only one able to effect even moderate regulation. The fact that in the second half of 1923 *Cynodon* transpires much more, but regulates less effectively, than in the first half of the same year, and that *Digitaria* is sometimes unable to regulate at all, is suggestive. It would appear as if these plants only succeed in regulating their transpiration under conditions which are not too extreme, but that with temperatures exceeding 33° C. they lose control and behave like the other grasses which do not even regulate at lower temperatures.

It might be argued that a soil moisture of 20 per cent. is excessive and that unfair comparison is being made between supra-optimal and sub-optimal conditions; but against this are the data for intermediate soil moistures and the fact that the plants developed best at the higher water-content. Still higher water-content of 30 per cent., the figure at which the Armoedsvlakte soil is fully saturated, is of course harmful, and in it the plants become yellow in a relatively short time.

It is easy to understand how dangerous is the incapacity of the generality of grasses to regulate their transpiration according to diminishing soil moisture. High water loss continues after the roots fail to keep up the supply, and the plants wither by losing water of constitution. It might have been anticipated that at the moment of wilting transpiration would diminish, but this is not the case (see Chart 4). Water output goes on at approximately the same rate, and only when the plants are nearly dry does the transpiration become abnormally low; then proceeding by fits and starts, as if displaying a pre-mortal behaviour of the leaves.

Under continued high transpiration of drooping leaves the plant of course loses further water of constitution and wilting is further accelerated. This peculiar behaviour is probably explained by the fact that the stomata are never completely closed, even under the most adverse conditions. Petroleum ether can penetrate everywhere, even when the leaves are altogether withered (Molisch, 1912).

In regard to *seasonal behaviour*, it is apparent from Table 2 that the grasses do not wilt at constant moisture all the year round. At the beginning of 1923 they rarely wilted at a soil moisture of 2 per cent. or less in pot experiments on transpiration. Under the more arid conditions of the end of 1923 temporary wilting was not uncommon at a soil moisture as high as 5 per cent. Wilting in pots of course depends greatly on the size of the pot and total available soil. Under identical extraneous conditions a plant in a big pot wilts much later than the same plant in a small pot, when the percentage of soil moisture is the same. This influence of absolute water-reserve must be remembered in drawing conclusions in regard to natural field conditions, and, in point of fact, the grasses growing in the open veld only withered finally when the natural soil moisture had fallen to 0.5 per cent. at the beginning of 1923, or to 3 per cent. in the hotter ensuing summer at the end of 1923.

The data of Table 2 may at first sight suggest that regulation of transpiration according to decreasing soil moisture is commoner than is made out in this discussion, particularly with *Eragrostis superba*. This is not really the case, since on analysing the table it will be noted that in the apparent exceptions (marked with an asterisk) to the general conclusion, small pots were used, and the plants therefore really limited by low absolute, as well as low relative, soil moisture.

Attention may be drawn to another striking feature of the data, i.e. that the transpiration values calculated on fresh matter do not always run parallel with those calculated on leaf surface. This is particularly noticeable, for instance, in Experiment 14 on *Themeda triandra*. It is probable that in considering soil moisture the values calculated upon the fresh matter are more important. The difference is due to variation in the thickness of the leaves of different plants, but how this anatomical difference arises it is difficult to say, especially since the different individuals were kept under very similar conditions.

*Direct Water Intake by Leaves.*—As already mentioned in discussing diurnal variation, the grasses increase in weight during dark nights. On all the observation nights of the early part of 1923 the relative humidity fell below the dewpoint, even during the driest weeks, but in the ensuing season dew was not registered at all before the November rains and was infrequent in December and January. In the former season permanent wilting did not occur once the grasses were properly up, while in the latter it was only too frequent. Dew certainly comes into consideration as a biological factor, and special experiments were therefore carried out to determine the intake of water in a very moist atmosphere. Cut leaves of *Cynodon dactylon*, *Tragus racemosus*, and *Eragrostis superba* were allowed to wilt to varying degrees in a blazing sun, and then transferred to the atmosphere of a bell jar standing over water in diffused light. The results were interesting. Leaves of *Tragus* and *Eragrostis*, which had lost over 50 per cent. of their fresh matter by wilting, regained so much water from the moist atmosphere that they returned to 80 per cent. of their original water-content. Under such conditions, however, they recommenced transpiration, so that their fresh matter was lower at the end of the experiment than after the first few hours. *Cynodon* behaved in the same way except that the water intake was not so large, although absorption already commenced at a loss of 40 per cent. as against 50 per cent. for the two preceding species. Both *Eragrostis* and *Tragus* continued to transpire if transferred to the moist atmosphere, after preliminary sun exposure sufficient to reduce their fresh matter by 30 to 50 per cent. After falling below 50 per cent. by further transpiration under the bell jar, a small compensating absorption occurred, but this was never so large as in the case of leaves badly wilted from the beginning, probably due to the adverse effect of long duration of experiments.

In the open veld the loss of water from the grasses generally reaches 50 per cent. by the time wilting occurs, and the conditions for water intake from dew are therefore created. Darkness and fall of temperature of course favour the process of absorption, since both factors depress transpiration. The numerous papilli on the upper side of the leaves also help to retain the dewdrops, and although this is probably not their only function, Marloth's view (1908, p. 303) that South African flora show many adaptations for catching dew can be endorsed. Fitting's remark (1911, p. 212) that plants which absorb water through their aerial parts, also part with it again very easily, is only too true for grasses. In January, 1923, the dew always disappeared shortly after sunrise, and the grasses were frequently withered by 8 a.m. Nevertheless, the few hours during which the moist condition is maintained in the presence of light are invaluable for carbon assimilation, a process which can hardly be regarded as occurring at all during the wilted state of the plant.

*Automatic Records with the Richard Balance.*—These lead to the same conclusions as the records obtained by manual weighing, and can therefore be briefly dismissed. They show pronounced seasonal variation in transpiration, with highest values from November, 1923, to February, 1924. In December no charts were obtained, owing to destruction of plants by the locust invasion. In general the grasses seemed to wilt at higher soil moisture in the Richard apparatus than in the twenty-four hour experiments with pots embedded in the adjoining earth, but this can probably be explained as due to differences in the leaf and soil temperatures. In the sheltered box used to protect the balance pans from the wind, the roots were probably too cool to provide the warm exposed leaves with sufficient water, whereas in the pots buried outside, the higher soil temperature accelerated water transport and presumably permitted more extensive abstraction of soil moisture. Under automatic registration the maximum transpiration was always recorded in the afternoon. A noon-time fall is not noticeable, probably because the balance is not sensitive enough to record it.

*Relative Transpiration.*—The data obtained in determinations of relative transpiration by the cobalt chloride method are recorded in Table 3 (Appendix). This method, already described, was adopted for the sake of comparing the water output of other plants in relation to that of grasses. The indices for transpiration power were calculated on the coefficient of Bakke (1914), i.e. the number obtained by dividing the standard time for colour change of cobalt papers over a water surface (see p. 676) by the average time for the same change on upper and lower leaf surfaces.

A glance at table 3 shows that the variations in the actual figures are great, but that under similar equable conditions of soil moisture and atmospheric "saturation deficit" * the indices are very similar. The plants, however, behave very differently with variations in meteorological and edaphic factors, and a direct separation into Mesophytes and Xerophytes would be difficult. Bakke defines Mesophytes as plants with indices over 0.69, and Xerophytes as plants with indices below 0.28. According to later views this division is no longer tenable since Maximow (1923) has found Xerophytes with a much larger transpiring power. Huber (1924) is of opinion that a plant from an arid region can be called a Xerophyte even if it does not limit its output of water, so long as it is able to balance its transpiration through high suction force of its roots. Division of opinion on this matter of nomenclature is rife in the literature, however, and since the transpiration of mangroves is high, Faber (1904) does not reckon them as Xerophytes, although they show compensating suction forces of over 200 atmospheres.

Apparently there are very different types of Xerophytes to consider. One group, such as succulents, transpires very little and fits the older definition. Another group, according to Maximow, transpires more than European Mesophytes and in all probability has a high suction force. Faber's mangrove has been actually shown to have both a very high transpiration and a very high suction force, and could, therefore, be legitimately added to the second group. Maximow himself emphasizes drought resistance as the essential criterion for Xerophytes, but this may be going too far since some plants can resist drought at the expense of their general welfare. In the case of the grasses investigated in Bechuanaland, alternate

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* The coefficient "Saturation Deficit," reckoned by the Assmann Tables (p. 2), as Saturated Aqueous Vapour Tension $\times \left(1 - \frac{\text{Relative Humidity}}{100}\right)$, is regarded by American authors as more significant than "Relative Humidity" when influence on growth and transpiration of plants is considered.

wilting by day and recovery by night is of frequent occurrence, but the general metabolism of the plants suffers considerably in the process. A better criterion for a Xerophyte might therefore be its *faculty for decreasing transpiration with decrease of available soil moisture,* and there is no doubt that such a definition would also fit Maximow's plants. Decrease of transpiration is probably the first step towards complete drought resistance. Plants which in the normal state have low suction force and are yet unable to limit transpiration according to the obtainable soil moisture, can in no case be extreme Xerophytes. According to these ideas the plants of Table 3 would then fall into the following groups:—

(1) Plants which have always, or at least at low saturation deficit (high relative atmospheric humidity), a small transpiration. These are certainly Xerophytes, and include *Helichrysum, Amphidoxa, and Stachys spathulata,* all three covered with thick white felt.

(2) Plants which have a low transpiration coefficient at low soil moisture and high saturation deficit; and a higher index at high soil moisture and small deficit. These are well adapted to an arid region and include *Cassia obovata, Elephantorrhiza Burchellii, Urginea rigidifolia, Commelina karrooica, Grewia cana, Bouchea pinnatifida,* and *Gazania longifolia.* Of these, *Urginea* belong to Maximow's group of strongly transpiring Xerophytes.

(3) A few plants which show low indices with dry soil and high saturation deficit (low atmospheric humidity). These include Compositae such as *Vernonia Kraussii* and *Geigeria obtusifolia.* The grasses do not come into this group, although *Chloris, Anthephora,* and *Themeda* have been observed to show similar behaviour in the dying or unhealthy state.

(4) The majority of the grasses, more than half the species examined, show indices over 0.28, and some even 0.69. Only a few are low, and these correspond to individuals under abnormal conditions of permanent wilting. The indices of both species of *Eragrostis* and of *Aristida* species are high. *Sporobolus* and *Themeda* have lower values, and represent the only two grasses which resisted the extreme drought of the summer 1923-24. None of the grasses have high suction force in the normal state, and nothing in their behaviour entitles them to be classed as Xerophytes. The species upon which highest suction force was noted is *Anthephora* (*cf.* companion paper on "Grass Wilting").

(5) A few plants, notably a yellow *Lactuca* and *Hermannia brachypetala,* which have very high transpiration coefficients. *Lactuca* shows 1.42, and *Hermannia* goes as high as 1.8. In this connexion it may be pointed out that the remark of Huber (1924, p. 69) to the effect that indices cannot rise above unity, is erroneous. In the conventional method of estimation, the standard is determined on paper 1 mm. away from the free water surface, but on the plant leaf the estimation is made by direct contact with the paper, and the colour change in the latter case can therefore proceed faster than in the former, under some circum-

stances. Of the two plants mentioned, *Lactuca* appears to be a Mesophyte which can only stand drought for a short time, since it died down a few days after the recorded index was determined. The high values reached by *Hermannia* are astonishing, but it must be remembered that under drought and strong insolation this plant takes up a specific "protection position" (*cf.* Part I on "Wilting") and then transpires much less.

The general conclusion which may be arrived at from a study of Table 3 is that some of the Armoedvlakte plants transpire as much as, or more than, grasses, when the soil is wet, but that the majority transpire less, or regulate their water output very efficiently when the soil is dry. A similar conclusion was arrived at by direct weighing experiments upon *Stachys spathulata, Falkia oblongata,* and *Limeum viscosum. Stachys* and *Limeum* transpired much less than grasses weighed at the same time. *Falkia,* in special distinction to the grasses, regulated its transpiration according to available soil moisture.

The Xerophytes of the shade, such as *Oxalis convexula,* may be briefly mentioned. *Oxalis* transpires fairly strongly when exposed to the sun. Its hourly average for absolute transpiration is recorded as 0.63 gm. per sq. dm., and its indices for relative transpiration are of the same order as for vigorously transpiring grasses. Young plants in particular show high water output.

In the Bechuanaland flora, succulents of low transpiring power are also represented. The records refer to absolute numbers since cobalt papers could not be readily fixed on the leaves. The hourly average for *Mesembryanthemum Lesliei* in moist soil is 0.0025 gm. per gm. of fresh matter.

By way of summary it may be stated that the Bechuanaland flora is generally of a Xerophytic nature. There are a few notable exceptions, of which the grasses are the most important since they are the economically significant plants from the point of view of stock rearing. Most strongly transpiring plants, other than grasses, are characterized by a high suction force in the normal state, which procures for them the necessary water. A few plants, such as *Bouchea pinnatifida,* display a low transpiration with a low suction force.

*Direct Wilting Experiments.*—Specific consideration of the direct wilting experiments again shows that the grasses do not regulate their transpiration according to the soil moisture available. Specimen protocols are given in Table 4. Only after withering has commenced does a marked decrease occur, and even on the first day of wilting the transpiration may continue vigorously. When exposed plants are allowed to recover from initial wilting by subjection to a moist atmosphere, and again exposed to the sun, transpiration may proceed in jerky fashion; by fits and starts down to the minimum value at which permanent wilting sets in.

The conditions controlling temporary and permanent wilting could readily be distinguished in February and March, 1924, since between each process a few days of strong transpiration intervened. In the larger experimental pots (500 gm.) temporary wilting actually occurred at betweeen 1.75 and 5 per cent. soil moisture; in the small bottles (50 gm.) at even higher percentages. This experiment was carried out at the end of a long drought period, a few days before a rainfall.

In the experiments carried out from September to October, and in December, 1924, temporary and permanent wilting occurred about the same time. Some of the observations were interrupted by rainy days which prolonged the exposure of the grasses for some weeks, but the individuals which wilted before the rains did so in a few days (Table 4). The water-content of the soil in the pots at the end of this series was much smaller than in the corresponding series of February. For permanent wilting the figures were determined as 0.5 per cent. moisture in the former and from 1.5 to 3 per cent. in the latter.

For single days, the recorded transpiration depends upon the prevailing meteorological conditions. Over several days, the output of water by the plant may vary very little, or may fluctuate widely. It is noteworthy that in the February-March experiment (Table 4) the highest transpiration values occur on the first day of observation; and in the experiment of the cooler September-October period, between the third and the fifth day. The factors responsible for subsequent diminution of transpiration, chiefly small root system and low water supply, then hasten wilting and the leaves collapse soon after the roots in the dry soil can no longer cope with their water output. It is striking that the plants which commenced the experiment on high soil moisture of over 15 per cent. wilt somewhat sooner than those which commenced with 8 to 10 per cent. This is probably due to wider opening of the stomata, and resembles a state of affairs frequently found under natural veld conditions. Veld grass which shoots in the rainy season is more liable to wilt under a subsequent blazing sun than grass which comes up from a dry soil in the rainless spring. In a short experiment such behaviour may hardly show at all, but it is well pronounced in observations which happen to extend over several weeks.

The average time in which various grasses wilt in big pots is fairly long for most species, but shorter for some. For the series of experiments executed, the average time was rather over fourteen days for *Themeda*, less than a day shorter for *Eragrostis* and *Digitaria*, but only three days altogether for *Sporobolus*. It may be added that most of the experiments on Themeda were conducted at much lower soil moisture (7-11 per cent.) than those on *Digitaria* and *Eragrostis* (17 per cent.), and its even longer survival is further evidence of its earlier mentioned resistance to drought. The short survival of *Sporobolus* is not easily explained since all individuals in experiment wilted under relatively high soil moisture. The statement made above, that well watered plants may wilt more quickly than others, applies with particular force to *Sporobolus*.

## General Discussion and Résumé.

From the locus of writing this article and the companion paper on "Wilting," it is impossible to consult the extensive literature on transpiration available in European libraries, and for many points of reference Burgerstein's textbook (1904 and 1920) had to be relied upon. Although a modicum of the most recent literature was procured from Europe, not all journals were available, and in considering the Armoedsvlakte experiments attention must be confined, for the time being at least, to certain recent papers which seem to have a special bearing upon their significance.

Iljin (1915 and 1916) and Maximow (1923 and 1924) were probably the first authors who treated the Xerophytic plant from a point of view entirely different to that of the ordinary textbooks. Although the South African data now recorded do not altogether bear out Maximow's views, the experiments themselves were carried out with due regard to his standpoint.

Huber (1924), whose excellent critical paper was only published towards the conclusion of the Bechuanaland work, actually points out that results different from Maximow's might possibly be obtained in the extreme drought areas of Africa, but apart from this he subscribes almost completely to the general views of the Russian author. He considers it characteristic of a Xerophyte (p. 49) that it can continue transpiration with open stomata even when the soil is drying out and the atmospheric saturation deficit is large, and that in arid areas it can retain its natural ventilation without danger to its water balance. The reduced transpiration as a distinction from Mesophytes loses its significance (p. 96) when Xerophytic characteristics occur, until finally, in extremely dry soil, it is only the osmotic forces which decide the retention of water balance. The more xeromorphic a plant the less important becomes the absolute saving effected by decreased transpiration.

These views of Huber, expressed so recently as last year, render it necessary to emphasize again the totally contradictory behaviour of the flora of Bechuanaland. Not one of the investigated plants is capable of extensive dehydration without vital changes in its metabolism, although these cannot be observed without analysing the plant itself, and may proceed even if the plant can still recover its turgescence through rain. In the area studied, an admirable place for Xerophytes, the only plants which keep the stomata open when the temperature is high, the relative humidity and the soil moisture low, are the grasses. All other plants close their stomata, and some even adopt protective positions. At the end of 1922, after a rainless period of ten months, when the country suggested the appearance of a real desert, *Elephantorrhiza*, *Bouchea*, *Cassia*, and *Stachys* were found with closed stomata; and the two Leguminosae adopted their characteristic protective positions (photographs in Part I on "Wilting"). Should these plants be refused the name of Xerophyte because they cease assimilation in the drought-stricken soil and desiccated air? Is it not wonderful that under such extreme conditions the plants were able to shoot new leaves, continue the metabolism for a few hours each day, but close their stomata for the rest of the time?

During this period, of course, no grasses could be found, but in no sense should they be classed as Xerophytes.

Huber emphasizes the fact that different plants by no means employ the same means of protection against drought. In South Africa diminished transpiration plays a relatively dominant rôle, perhaps because some of the most drought-resistant plants have very thin leaves which cannot stand alternate drying out and recovery. It seems probable, however, that the subterranean parts of all these plants are drought resistant in the sense of Maximow and Huber, and that it is this, together with their high suction force, which enables them to shoot in an extremely dry soil.

The grasses, which should be separated altogether from the Xerophytes, do behave somewhat like plants which Maximow includes under that term. They continue, at least to a limited extent, their gaseous metabolism right up to the point at which their continued transpiration of water results in permanent withering. Before this point their metabolism is not reduced to a few specific hours each day, but continues all day long in a disturbed fashion. The nature of the disturbance can of course only be revealed by chemical analysis, in which direction certain data are being now accumulated. When the grasses suffer only temporary wilting they may recover completely after rain, so far as external appearance goes; but their metabolism is not restored to normal at the same rate. It is not known at present, in how far the drying out of the plants in Maximow's experiments affects their metabolism, but from the researches of Iljin (1923) some influence would be expected. It seems that the metabolic consequences of alternate dehydration and recovery will have to be investigated before any definite conclusion can be arrived at, concerning the relative advantages to the plant of a capacity to decrease transpiration, and a capacity to lose water at one period which it can regain at another.

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## LITERATURE.


1914.—Aspirations-Psychrometer-Tafeln herausgegeben vom preussischen meteorologischen Institut. 2 te Aufl.

1914.—Blackman, V. H. The wilting coefficient of the soil. *Journal of Ecology II*, pp. 43-50.

1914.—Bakke, A. L. Studies on the transpiration power of plants as indicated by the method of standardized hygrometric paper. *Journal of Ecology II*, pp. 145-173.

1912. Briggs, Lyman I, and Shantz, H. L. The relative wilting coefficient for different plants. *Botanical Gazette*, 1912, pp. 229-235.

1904 and 1920.—Burgerstein, Alfred. Die Transpiration der Pflanzen. Jena. G. Fischer.

1923.—Faber, C. F. Die Physiologie der Mangroven. *Berichte d. deutschen botanischen Gesellschaft*, 41, pp. 227–234.

1923.—Henrici, M. Die Transpiration einiger Gräser in Bechuanaland. *Verandl. d. Naturforschenden Gesellschaft*, Basel, Band XXXV, pp. 356-373.

1924.—Huber Bruno. Die Beurteilung des Wasserhaushaltes der Pflanze. *Jahrbücher für wissenschaftliche Botanik*, Bd. 64, pp. 1-120.

1915.—Iljin, W. L. Die Probleme des vergleichenden Studiums der Pflanzentranspiration. *Beihefte zum botanischen Centralblatt*, 32, I, p. 36. Not seen myself, cited after Huber.

1916.—Iljin, W. L. Relation of transpiration to assimilation in steppe plants. *Journal of Ecology IV*, pp. 65-82.

1923.—Iljin, W. S. Der Einfluss des Wassermangels auf die Kohlenstoffassimilation durch die Pflanzen. *Flora*, 16, pp. 360-378.

1923.—Iljin, W. S. Einfluss des Welkens auf die Atmung der Pflanzen. *Flora*, Vol. 16, pp. 379-403.

1922.—Knight, R. C. Further observations on the transpiration, stomata, leafwater-content, and the wilting of the plant. *Annals of Botany*, Vol. XXXVI, pp. 361-83.

1912.—Livingston, B. E. The resistance offered by leaves to transpirational water loss. *The Johns Hopkins University Circular*, 2, pp. 11-13.

1912.—Livingston, B. E., and Brown, W. H. Relation of the daily march of transpiration in the water-content of foliage leaves. *The Johns Hopkins University Circular*, 2, pp. 21-23.

1912.—Livingston, B.E., and Brown, W. H. The same in *Botanical Gazette*, 53, pp. 309-330.

1913.—Livingston, B. E. The resistance offered by leaves to transpirational water loss. *Plant World*, 16, pp. 1-35.

1914.—Livingston, B. E., and Hopping, Aleita. Permanent standardization of cobalt chloride paper for use in measuring the transpiration power of plant surfaces. Carnegie Inst., Washington. *Year Book*, 13.

1916.—Livingston, B. E., and Shreve, E. B. Improvements in the method for determining the transpiration power of the plant surfaces by hygrometric paper. *Plant World*, 19, pp. 287-309.

1917.—Livingston, B. E. Incipient drying and temporary and permanent wilting of plants related to external and internal conditions. *The Johns Hopkins University Circular*, 3, pp. 176-182.

1923.—Maximow, N. A. Physiologisch-ökologische Untersuchungen über die Dürreresistenz der Xerophyten. *Jahrbücher für wissenschaftliche Botanik*, 62, pp. 128-143.
veranschaulicht durch eine neue Methode (Infiltrationsmethode). in connexion with drought resistance. *Journal of Ecology*, XII, pp. 95-109.

1912.—Molisch, H. Das Öffnen und Geschlossensein der Spaltöffnungen, veranschaulicht durch eine neue Methode (Infiltrationsmethode). *Zeitschr. für Botanik*, Bd. 4, S. 106-122.

1923.—Shreve, Edith B. Seasonal changes in the relations of desert plants. *Ecology*, IV, pp. 266-292.

1922.—Senn, Gustav. Untersuchungen über die Physiologie der Alpenpflanzen. Separatum aus Verhandl. der Schweizer Naturforschenden Gesellschaft. Bern 1922, II. Teil.

## APPENDIX.

### EXPLANATION OF TABLES.

TABLE 1: Hourly average values of the grasses in grams per 100 cm.$^2$ surface.

TABLE 2: Dependence of transpiration of grasses on the soil moisture.

The plants in small pots are marked with an asterisk in the column headed "state of the plant."

In the 4th column the soil moisture is given in percentages, in the 5th the ratio of the aerial parts to suction roots, in the 6th and 7th the amount of water transpired in twenty-four hours per 1 grm. fresh matter, or per 100 sq. cm. leaf surface. In the 8th column the condition of the grass leaves is marked.

TABLE 3: Relative transpiration of different plants in comparison with grasses.

The experiments are arranged according to dates (column 1). In column 2 the name of the plant, in column 3 the temperature of the air in ° C., in column 4 the saturation deficit of the air are marked. The latter is given because in most recent investigations on transpiration *this factor* and *not the air moisture* is discussed.

In the following columns the transpiration coefficient is calculated according to Bakke, as explained on page 685.

TABLE 4: Course of a wilting experiment.

In table 4 the records of two plants during a wilting experiment are given. As it is impossible to reprint all the records, these serve as general example. They are taken from two different experiments (October and February). In column 1 are given the data, in 2 the number of the day, in 3 the daily output of water per 1 grm. fresh matter in grms., in 4 the same per 100 cm. leaf surface, in 5 the soil moisture, in 6 the maximum temperature, in 7 the minimum temperature, both in ° C.; in 8 the lowest air moisture.

The difference of soil moisture at the time of wilting for the two plants is obvious. *Digitaria* in a small pot wilts at 8·5 %, *Eragrostis* in a big pot at 1·2 %.

TABLES 5 and 6: Records of experiment 39.

As it is quite impossible to reprint all the records, experiment 39 is given as example. It cannot be expected that every case is illustrated in a single record. The whole experiment is given except the direct weighings. Page 700 contains the meteorological data of the day. In the 1st column the time is given, in the 2nd the sun is marked with the usual meteorological sign, in the 3rd the velocity of the wind is indicated in degrees on Beaufort scale, in the 4th the soil temperature, in the 5th the air temperature in ° C., and in the 6th the air moisture.

On page 699 the units of weight and surface, and the soil moisture, are given. In the last column the condition of the plants is described.

On pages 700 to 702 the results are given for eight plants. For each plant is marked in the 1st column the time of exposure, in the 2nd column the hourly transpiration in grms. per 1 grm. fresh matter, and in the 3rd the hourly transpiration in grm. per 100 cm$^2$. surface.

Page 699 gives the daily transpiration value per 1 grm. fresh matter and 100 sq. cm. surface. In the last column the probable factors determining the result are indicated. The values calculated on fresh matter agree much better than those calculated on surface, as was pointed out on page 683.

TABLE 1.

*Hourly Average Value of the Grasses in gr.* pro *cm.*² *Surface.*

| Plant. | Jan. | Feb. | Mar. | April. | May. | June. | July. | Oct. | Nov. | Dec. | Average. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Eragrostis superba*... | 0·46<br>0·89† | 0·52 | | 0·26 | 0·16 | 0·19 | 0·09 | 0·64 | 0·95 | 1·04 | 0·52 |
| *Digitaria eriantha*.... | 0·72† | | | | 0·61 | 0·08 | 0·19 | 0·60 | 0·35* | 0·6 | 0·45 |
| *Themeda triandra*.... | 0·84† | 0·78 | | 0·58 | | 0·16 | | | | | 0·59 |
| *Aristida uniplumis*... | 0·72† | | | | | | | | | | 0·72 |
| *Sporobolus fimbriatus* | 0·70† | | | | | | | | | 0·53 | 0·61 |
| *Cymbopogon plurinodis*......... | 0·56† | | | | | | | | | | 0·56 |
| *Cynodon dactylon*.... | | 0·4 | | 0·24 | 0·22 | | | 0·78 | 0·88 | 0·26 | 0·46 |
| *Tragus racemosus*.... | 0·66 | 0·56 | 0·85 | | | | | | | | 0·64 |
| *Panicum Marlothii*.. | 0·59 | | | | | | | | | | 0·59 |

* Wilted plants. † 1924.

TABLE 2.

*Dependence of Transpiration of Grasses on the Soil Moisture.*

| No. | Date. | Plant. | Soil Moisture in per Cent. | Coefficient Aerial Parts to Suction Roots. | Amount of Water transpired in 24 hrs. *pro* 1 gr. Fresh Matter. | Amount of Water transpired in 24 hrs. *pro* 100 cm.² Surface. | State of Plant. |
|---|---|---|---|---|---|---|---|
| 12 | 28.3.23 | *Tragus racemosus* | 4·1 | — | 14·52 | 10·0 | Fresh. |
| | | ,, ,, | 3·0 | — | 5·5 | 17·3 | ,, |
| | | ,, ,, | 17·0 | — | 11·37 | 20·8 | ,, |
| | | ,, ,, | 20·8 | — | 23·63 | 22·0 | ,, |
| | | ,, ,, | 19·4 | — | 10·66 | 21·2 | ,, |
| | | ,, ,, | 23·3 | — | 17·82 | 20·8 | ,, |
| 14 | 15.4.23 | *Eragrostis superba* | 1.87 | 0·3 | 2·9 | 5.0 | Rolled during daytime. |
| | | ,, ,, | 16·6 | 0·5 | 4·3 | 6·4 | Fresh. |
| | | *Themeda triandra* | 7·8 | 1·2 | 9·1 | 5·8 | During day-time, half folded. |
| | | ,, ,, | 12·8 | 0·2 | 7·4 | 9·2 | Fresh. |
| 17 | 26.4.23 | *Cynodon dactylon* | 2·0 | 0·7 | 0·66 | 1·5 | Fresh. |
| | | ,, ,, | 10 | 0·6 | 2·68 | 8·79 | ,, * |
| | | ,, ,, | 8 | 0·18 | 2·19 | 2·9 | ,, * |
| 20 | 4.5.23 | *Eragrotis superba* | 5 | 0·89 | 3·59 | 17·1 | Fresh. |
| | | ,, ,, | 8 | 2·36 | 2·21 | 5·6 | ,, |
| | | *Digitaria eriantha* | 20 | 1·03 | 4·82 | 5·3 | ,, * |
| | | ,, ,, | 25 | 1·05 | 1·73 | 5·8 | ,, * |
| 23 | 16.5.23 | *Eragrostis superba* | 17 | 0·77 | 8·7 | 10·1 | Fresh. * |
| | | ,, ,, | 24 | 0·5 | 33·5 | 11·9 | ,, * |
| | | *Cynodon dactylon* | 19·6 | 1·4 | 2·2 | 4·8 | ,, * |
| | | ,, ,, | 22·6 | 1·7 | 2·0 | 5·7 | ,, * |
| 25 | 24.5.23 | *Eragrostis superba* | 27·8 | 4·6 | 0·93 | 3·5 | Fresh. * |
| | | ,, ,, | 11·1 | 4·6 | 1·56 | 4·2 | ,, * |
| | | *Digitaria eriantha* | 29·8 | 28·0 | 7·2 | 7·1 | ,, * |
| | | ,, ,, | 24·0 | 4·2 | 2·0 | 4·8 | ,, * |

* In small pots.

TABLE 2—(*continued*).

| No. | Date. | Plant. | Soil Moisture in per Cent. | Coefficient Aerial Parts : Suction Roots. | Amount of Water transpired in 24 hrs. *pro* 1 gr. Fresh Matter. | Amount of Water transpired in 24 hrs. *pro* 100 cm.$^2$ Surface. | State of Plant. |
|---|---|---|---|---|---|---|---|
| 29 | 11.6.23 | *Eragrostis superba* | 21·9 | 3·0 | 2·7 | 6·1 | Fresh.* |
| | | ,, ,, | 18·1 | 0·6 | 1·6 | 2·9 | ,, * |
| | | *Digitaria eriantha* | 21·4 | 1·4 | 0·82 | 2·0 | Fresh; but plant had suffered before by frost. |
| | | ,, ,, | 8·7 | 0·4 | 0·6 | 2·0 | Fresh. * |
| | | *Themeda triandra* | 26·5 | 1·4 | 4·7 | 5·3 | ,, * |
| | | ,, ,, | 21·0 | 1·4 | 1·3 | 2·3 | Plant curled; affected by frost. |
| 30 | 18.6.23 | *Digitaria eriantha* | 26·8 | 0·95 | 3·5 | 5·3 | Fresh. * |
| | | ,, ,, | 15·6 | 0·5 | 2·9 | 3·7 | ,, * |
| | | *Eragrostis superba* | 29·9 | 1·4 | 0·6 | 2·4 | ,, * |
| | | ,, ,, | 11·7 | 2·4 | 0·6 | 2·1 | ,, * |
| 31 | 3.10.23 | *Cynodon dactylon* | 5·91 | 1·2 | 11·9 | 21·7 | Fresh. |
| | | ,, ,, | 1·7 | 1·1 | 4·2 | 10·5 | ,, |
| | | ,, ,, | 5·3 | 1·2 | 8·2 | 28·0 | ,, |
| | | ,, ,, | 0·7 | 0·5 | 6·9 | 15·7 | ,, |
| | | *Eragrotis superba* | 3·6 | 0·64 | 1·5 | 5·6 | Dry, and grey-green during day.* |
| | | ,, ,, | 22·2 | 0·6 | 18·8 | 33·8 | Fresh. * |
| | | ,, ,, | 0·4 | 0·4 | 0·4 | 0·8 | Dry, and grey-green during day.* |
| 32 | 18.10.23 | *Eragrostis superba* | 6·5 | 0·84 | 3·9 | 8·1 | Rolled in day-time.* |
| | | ,, ,, | 19·5 | 1·9 | 11·6 | 19·6 | Fresh. * |
| | | ,, ,, | 5·2 | 1·5 | 3·8 | 12·2 | Rolled in day-time.* |
| | | ,, ,, | 30·1 | 1·3 | 14·2 | 20·7 | Fresh. |
| | | *Digitaria eriantha* | 24·6 | 2·9 | 15·5 | 23·9 | ,, * |
| | | ,, ,, | 10·2 | 0·45 | 1·6 | 1·5 | Dry from the beginning; did not recover in spite of additional water.* |
| | | ,, ,, | 19·8 | 4·0 | 14·4 | 21·3 | Fresh. * |
| | | ,, ,, | 2·8 | 2·5 | 6·4 | 10·5 | Drooping, but much better than No. 2; no water added.* |
| 33 | 25.10.23 | *Cynodon dactylon* | 2·4 | 1·1 | 9·9 | 17·4 | Fresh. |
| | | ,, ,, | 8·1 | 0·75 | 15·9 | 22·4 | ,, |
| | | ,, ,, | 7·9 | 1·38 | 17·3 | 23·0 | ,, |
| | | ,, ,, | 6·6 | 2·0 | 13·8 | 23·7 | ,, |
| | | *Digitaria eriantha* | 8·7 | 3·8 | 9·6 | 15·9 | ,, * |
| | | ,, ,, | 5·2 | 2·0 | 7·1 | 10·5 | ,, |
| | | ,, ,, | 2·9 | 1·8 | 1·7 | 2·2 | Drooping during day.* |
| | | ,, ,, | 10·9 | 2·5 | 7·8 | 15·7 | Fresh.* |
| 34 | 15.11.23 | *Eragrostis superba* | 11·0 | 3·5 | 9·5 | 32·5 | Fresh. |
| | | ,, ,, | 0·5 | 0·8 | 5·6 | 10·7 | Wilted during day.* |
| | | ,, ,, | 4·0 | 0·7 | 10·7 | 16·0 | Wilted for few hours.* |
| | | *Digitaria eriantha* | 5·8 | 0·8 | 0 | 0 | Taken wilted in the experiment.* |
| | | ,, ,, | 13·6 | 2·2 | 8·9 | 6·2 | Fresh.* |
| | | ,, ,, | 3·5 | 1·0 | 1·3 | 0·8 | Taken wilted in the experiment.* |
| | | ,, ,, | 13·0 | 9·3 | 7·9 | 17·4 | Fresh.* |

* In small pots.

TABLE 2—(*continued*).

| No. | Date. | Plant. | Soil Moisture in per Cent. | Coefficient Aerial Parts to Suction Roots. | Amount of Water transpired in 24 hrs. *pro* 1 gr. Fresh Matter. | Amount of Water transpired in 24 hrs. *pro* 100 cm.$^2$ Surface. | State of Plant. |
|---|---|---|---|---|---|---|---|
| 35 | 3.12.23 | *Eragrostis superba* | 4·5 | 4·4 | 8·0 | 22·6 | Inner young leaves rolled during day-time. |
| | | „ „ | 16·2 | 2·1 | 14·5 | 30·8 | Fresh. |
| | | „ „ | 1·5 | 1·7 | 4·4 | 34·2 | Rolled.* |
| | | *Digitaria eriantha* | 4·8 | 4·0 | 14·0 | 32·0 | Drooping in the after-noon, recovered during night. |
| | | „ „ | 16·5 | 2·1 | 10·0 | 17·8 | Fresh. |
| | | „ „ | 3·0 | 3·1 | 6·1 | 9·5 | Drooping in the after-noon, recovered during night. |
| | | „ „ | 22·3 | 1·2 | 10·0 | 18·8 | Fresh. |
| 36 | 20.12.23 | *Digitaria eriantha* | 1·7 | 1·9 | 3·2 | 5·6 | Drooping badly. |
| | | „ „ | 8·5 | 6·5 | 5·8 | 14·0 | Fresh.* |
| | | *Cynodon dactylon* | 9·2 | 4·3 | 3·4 | 6·3 | „ |
| | | „ „ | 21·4 | 5·6 | 3·7 | 6·2 | „ |
| | | *Eragrostis superba* | 6·3 | 0·5 | 8·5 | 15·5 | Rolled over day-time. |
| | | „ „ | 24·2 | 0·9 | 6·4 | 20·0 | Fresh. |
| | | *Sporobolus fimbriatus* | 3·3 | 5·7 | 4·3 | 8·6 | Leaves folded. |
| | | „ „ | 14·7 | 6·6 | 6·5 | 17·2 | Fresh. |
| 38 | 3.1.24 | *Themeda triandra* | 18·8 | 1·2 | 13·5 | 21·6 | Fresh. |
| | | „ „ | 9·9 | 2·0 | 10·6 | 22·8 | „ |
| | | „ „ | 10·2 | 0·9 | 17·5 | 16·7 | „ |
| | | *Eragrostis superba* | 6·0 | 0·7 | 10·3 | 29·0 | „ |
| | | „ „ | 26·2 | 1·3 | 13·4 | 31·6 | „ * |
| | | *Sporobolus fimbriatus* | 13·1 | 0·7 | 29·5 | 32·5 | „ |
| | | „ „ | 9·8 | 5·6 | 8·9 | 23·8 | „ |
| | | „ „ | 4·0 | 5·0 | 4·3 | 13·9 | Leaves folded at noon. |
| 39 | 15.1.24 | *Digitaria eriantha* | 4·0 | 1·75 | 1·7 | 1·7 | Drooping; better the second day. |
| | | „ „ | 9·1 | 2·3 | 13·4 | 37·7 | Fresh. |
| | | „ „ | 5·7 | 5·6 | 7·8 | 13·7 | Drooping; good the second day. |
| | | „ „ | 16·6 | 2·4 | 10·0 | 25·0 | Fresh. |
| | | *Eragrostis superba* | 4·8 | 6·1 | 4·6 | 10·3 | Folded or rolled, but not dry. |
| | | „ „ | 13·9 | 1·1 | 6·3 | 11·7 | Good; leaves apex from the beginning dry. |
| | | „ „ | 4·6 | 0·75 | 1·7 | 5·2 | Rolled; better on the second day. |
| | | „ „ | 9·5 | 0·5 | 5·9 | 22·3 | Fresh. |
| 40 | 23.1.24 | *Cymbopogon plurinodis* | 6·4 | 3·3 | 6·2 | 13·7 | |
| | | „ „ | 10·3 | 2·6 | 5·5 | 12·2 | * |
| | | „ „ | 6·6 | 7·0 | 4·2 | 15·7 | Half folded in the afternoon. |
| | | *Sporobolus fimbriatus* | 2·3 | 4·5 | 7·8 | 14·0 | |
| | | „ „ | 2·2 | 6·0 | 3·5 | 6·3 | * |
| | | *Digitaria eriantha* | 4·7 | 3·0 | 5·9 | 11·4 | |
| | | „ „ | 17·0 | 2·8 | 10·7 | 20·0 | |

* In small pots.

TABLE 3.

***Relative Transpiration of Different Plants in Comparison with Grasses.***

| Date. | Plant. | Temperature in ° C. | Saturation Deficit of the Air. | Transpiration Coefficient (according to Bakke). Upper Surface. | Under Surface. | Average. | Remarks. |
|---|---|---|---|---|---|---|---|
| 3.11.23. 10.45–12.45 p.m. | *Cassia obovata*....... | 30·2 | 26·0 | 0·008 | 0·130 | 0·069 | |
| | *Elephantorrhiza Burchellii* | 30·6 | 29·3 | 0·000 | 0·000 | 0·000 | After 5 hours. |
| | *Anthephora pubescens* | 30·6 | 29·3 | 0·062 | 0·033 | 0·048 | Grass nearly dry. |
| 5.11.23. 8–9.30 a.m. | *Eragrostis superba*... | 32·8 | 31·7 | 0·312 | 0·277 | 0·294 | |
| | *Elephantorrhiza Burchellii* | 32·8 | 31·7 | Closed | 0·000 | 0·000 | |
| | If opened artificially, the closed leaf were | exposing t apparently | he upper not close | surface, d on the | index 0· protecte | 119; the d side. | stomata of |
| 23.11.23. 9.22 a.m... | *Elephantorrhiza Burchellii* | 21·0 | 10·07 | 0·123 | 0·127 | 0·125 | |
| 10.2 a.m... | *Eragrostis superba*... | 23·4 | 12·52 | 0·184 | 0·036 | 0·110 | |
| 10.18 a.m.. | *Sporobolus fimbriatus*. | 23·4 | 12·52 | 0·279 | 0·126 | 0·202 | |
| | *Grewia cana*......... | — | — | 0·140 | 0·238 | 0·189 | |
| | *Urginea rigidifolia*.. | — | — | 1·400 | 2·330 | 1·965 | |
| | *Anthericum spec*..... | 25·0 | 13·00 | 0·116 | 0·304 | 0·210 | |
| 2.1.24. 11.45 a.m.. | *Urginea rigidifolia*... | 37·0 | 41·68 | 0·020 | 0·006 | 0·013 | |
| 11.55 a.m.. | *Elephantorrhiza Burchellii* | 37·0 | 41·68 | 0·000 | 0·014 | 0·007 | |
| 12.10 p.m. | *Sporobolus fimbriatus*. | 38·2 | 44·21 | 0·008 | 0·022 | 0·015 | Completely dry. |
| 12.20 p.m.. | *Solanum supinum*... | 38·2 | 44·21 | 0·125 | 0·018 | 0·071 | |
| 22.3.24. 10.55 a.m.. | *Elephantorrhiza Burchellii* | 27·0 | 11·5 | 0·170 | 0·189 | 0·180 | |
| 11.12 a.m.. | *Bouchea pinnatifida*.. | 27·0 | 11·5 | 0·365 | 0·368 | 0·367 | |
| 11.45 a.m.. | *Brachiaria Marlothii*. | 27·0 | 11·5 | 0·094 | 0·289 | 0·191 | |
| 11.52 a.m.. | *Limeum viscosum*.... | 27·0 | 11·5 | 0·271 | 0·516 | 0·394 | |
| | *Eragrostis superba*... | — | — | 0·565 | 0·520 | 0·537 | |
| 11.56 a.m.. | *Alternanthera Achyrantha* | 27·0 | 11·5 | 0·342 | 0·480 | 0·411 | |
| | *Tribulus terrestris*... | — | — | 0·301 | 0·383 | 0·342 | |
| 12.4 p.m... | *Hermannia brachypetala* | — | — | 0·175 | 0·194 | 0·185 | |
| 12.10 p.m.. | *Euphorbia sanguinea* | — | — | 0·375 | 0·710 | 0·542 | |
| 12.15 p.m.. | *Giesekia pharnaceoides* | 26·8 | 8·46 | 0·224 | 0·547 | 0·386 | |
| 12.20 p.m.. | *Zisyphus Zeyheriana*. | 26·8 | 8·46 | 0·701 | 0·377 | 0·539 | |
| 12.26 p.m.. | *Oxalis convexula*..... | — | — | 0·657 | 0·771 | 0·714 | |
| 12.29 p.m.. | *Commelina Africana*.. | — | — | 1·312 | 0·888 | 1·100 | |
| 12.34 p.m.. | *Chrysopogon*......... | 27·2 | 9·47 | 0·422 | 0·471 | 0·447 | |
| 3.5.24. 11.20 a.m.. | *Cassia obovata*....... | 16·6 | 10·02 | 0·538 | 0·374 | 0·456 | |
| | *Themeda triandra*.... | 16·6 | 10·02 | 0·385 | 0·755 | 0·570 | |
| | " " | — | — | 1·129 | — | — | Near midrib. |
| 11.23 a.m.. | *Stachys spathulata*... | 16·6 | 10·02 | 0·102 | 0·091 | 0·097 | |
| | *Tragus koelerioides*.. | 16·6 | 10·2 | 0·515 | 0·534 | 0·525 | |
| | " " .. | — | — | 1·930 | — | — | Apex. |
| | *Hermannia brachypetala* | — | — | 1·039 | 0·883 | 0·961 | |
| | *Cynodon Dactylon*.... | — | — | 0·325 | 0·218 | 0·272 | |
| | " " .. | — | — | 0·608 | — | — | Apex. |
| 11.40 a.m.. | *Salvia rugosa*....... | 23·8 | 16·43 | 0·318 | 0·596 | 0·407 | |
| | *Eragrostis lehmanniana* | 23·8 | 16·43 | 0·329 | 0·656 | 0·492 | |
| 12.00 a.m.. | *Oxalis convexula*..... | 23·8 | 16·43 | 0·241 | 0·163 | 0·202 | |
| | *Digitaria eriantha*.... | — | — | 0·122 | 0·109 | 0·116 | Old. |
| | *Bouchea pinnatifida*.. | — | — | 0·093 | 0·284 | 0·189 | |
| | *Elephantorrhiza Burchellii* | — | — | 0·138 | 0·222 | 0·180 | |
| 12.20 p.m.. | *Anthephora pubescens* | 23·8 | 16·43 | 0·256 | 0·322 | 0·289 | Old. |
| 28.8 24. 3.10 p.m... | *Themeda triandra*.... | 19·2 | 11·5 | 0·137 | 0·266 | 0·202 | |
| | " " .... | 19·2 | 11·5 | 0·470 | 0·666 | 0·568 | Midrib. |
| | *Sporobolus fimbriatus* | 19·2 | 11·5 | 0·178 | 0·149 | 0·164 | |
| | " " | 19·2 | 11·5 | — | 0·370 | — | Midrib. |
| | *Stachys spathulata*... | 19·2 | 11·5 | 0·833 | 0·244 | 0·539 | |
| | *Euphorbia sanguinea* | 19·2 | 11·5 | 0·249 | 0·333 | 0·291 | |

TABLE 3.—*continued.*

| Date. | Plant. | Temperature in ° C. | Saturation Deficit of the Air. | Transpiration Coefficient (according to Bakke). Upper Surface. | Under Surface. | Average. | Remarks. |
|---|---|---|---|---|---|---|---|
| 28.8.24.—(*contd*). | | | | | | | |
| 3.40 p.m... | *Digitaria eriantha*.... | 19·2 | 11·5 | 0·384 | 0·416 | 0·395 | |
| | *Helichrysum caespititium* | 19·2 | 11·5 | 0·049 | 0·108 | 0·074 | |
| | *Oxalis convexula*.... | 19·2 | 11·5 | 1·956 | 0·607 | 1·282 | Very young. |
| | *Eragrostis superba*... | 19·2 | 11·5 | 0·300 | 0·218 | 0·259 | |
| | *Hermannia brachypetala* | 19·2 | 11·5 | 2·700 | 0·900 | 1·800 | |
| | *Aristida congesta*..... | 19·2 | 11·5 | 0·457 | 0·130 | 0·294 | |
| | *Geigeria passerinoides* | 18·2 | 11·7 | 0·372 | 0·592 | 0·482 | |
| 2.9.24. | | | | | | | |
| 3 p.m...... | *Gazania longifolia*.... | 25·2 | 21·8 | 0·142 | 0·134 | 0·138 | |
| | *Salvia rugosa*....... | 25·2 | 21·8 | 0·404 | 0·545 | 0·475 | |
| | *Themeda triandra*.... | 25·2 | 21·8 | 0·200 | 0·290 | 0·245 | |
| | *Digitaria eriantha*.... | 25·2 | 21·8 | 0·400 | 0·114 | 0·257 | |
| 3.30 p.m... | *Aristida congesta*..... | 25·2 | 21·8 | 1·250 | 0·483 | 0·867 | |
| | *Anthephora pubescens* | 25·2 | 21·8 | 0·235 | 0·195 | 0·215 | |
| | *Tragus racemosus*.... | 25·2 | 21·8 | 0·250 | 0·226 | 0·239 | |
| | *Geigeria obtusifolia*... | 25·2 | 21·8 | 0·105 | 0·222 | 0·164 | |
| 4.13 p.m... | *Eragrostis lehmanniana* | 25·2 | 21·8 | 0·785 | 0·234 | 0·510 | |
| 4.30 p.m... | *Euphorbia sanguinea*. | 22·8 | 18·5 | 0·348 | 0·694 | 0·521 | |
| | *Hermannia brachypetala* | — | — | 0·585 | 0·263 | 0·424 | |
| 22.10.24. | | | | | | | |
| 9.40 a.m... | *Themeda triandra*.... | 22·2 | 10·24 | 0·310 | 0·125 | 0·218 | |
| | *Amphidoxa gnaphaloides* | — | — | 0·059 | 0·111 | 0·085 | |
| | *Elephantorrhiza Burchellii* | — | — | 0·489 | 0·238 | 0·364 | |
| | *Rhynchosa confusa*... | — | — | 0·464 | 0·188 | 0·326 | |
| | *Cassia obovata*....... | — | — | 0·386 | 0·207 | 0·297 | |
| | *Salvia rugosa*........ | — | — | 0·579 | 0·250 | 0·415 | |
| | *Stachys spathulata*... | — | — | 0·580 | 0·500 | 0·540 | |
| | *Anthephora pubescens* | — | — | 0·153 | 0·260 | 0·207 | |
| | *Tragus koelerioides*... | — | — | 1·9 | 0·826 | 1·363 | |
| | *Digitaria eriantha*.... | — | — | 0·171 | 0·285 | 0·228 | |
| | *Gazania longifolia*.... | — | — | 0·177 | 0·467 | 0·322 | |
| | *Aristida uniplumis*... | — | — | 1·073 | 0·590 | 0·842 | |
| | *Hermannia brachypetala* | — | — | 0·961 | 1·192 | 1·077 | |
| | *Bouchea pinnatifida*.. | — | — | 0·411 | 0·231 | 0·321 | |
| 11.08 a.m.. | *Geigeria obtusifolia*... | 25·2 | 14·91 | 1·100 | 0·733 | 0·917 | |
| 6.1.25 | | | | | | | |
| 10.27 a.m.. | *Anthephora pubescens* | 33·5 | 27·58 | 0·244 | 0·084 | 0·164 | Folded. |
| 10.35 a.m.. | *Eragrostis lehmanniana* | — | — | 0·550 | 0·146 | 0·348 | Rolled. |
| 10.39 a.m.. | *Bouchea pinnatifida*.. | — | — | 0·043 | 0·022 | 0·033 | |
| 10.55 a.m.. | *Themeda triandra*.... | — | — | 0·354 | 0·105 | 0·230 | Folded. |
| 11.05 a.m.. | *Digitaria eriantha*.... | — | — | 0·447 | 0·188 | 0·317 | Half closed. |
| 11.10 a.m.. | *Salvia rugosa*....... | — | — | 0·213 | 0·448 | 0·330 | |
| 11.15 a.m.. | *Chloris petraea*...... | — | — | 0·173 | 0·071 | 0·122 | Partly closed. |
| 11.24 a.m.. | *Sporobolus fimbriatus* | 38·5 | 39·33 | 0·400 | 0·153 | 0·277 | Rolled. |
| | " " | — | — | 0·200 | — | — | Some. |
| 11.35 a.m.. | *Elephantorrhiza Burchellii* | 39·5 | 44·18 | 0·0008 | 0·018 | 0·0094 | Closed. |
| 12.1.25. | | | | | | | |
| 10.02 a.m.. | *Lactuca spec*........ | 31·7 | 25·0 | 1·500 | 1·35 | 1·425 | |
| 10.02 a.m. | *Eragrostis lehmanniana* | 31·7 | 25·0 | 0·468 | 0·107 | 0·288 | |
| 10.13 a.m. } 2.15 p.m. } | *Commelina karrooica*. | 31·7–36·5 | 25–33·4 | 0·102 | 0·001 | 0·050 | |
| 10.22 a.m.. | *Eragrostis superba*... | 31·7 | 25–33·4 | 1·20 | 0·240 | 0·720 | |
| 10.40 a.m.. | *Cassia obovata*....... | 34·0 | 28·0 | 0·05 | 0·138 | 0·071 | |
| 10.42 a.m.. | *Sporobolus fimbriatus*. | 36·50 | 33·4 | 0·209 | 0·209 | 0·209 | |
| 11 a.m.... | *Vernonia kraussii*.... | 36·5 | 33·4 | 0·021 | 0·191 | 0·105 | |
| 11.10 a.m.. | *Grewia cana Spots*.. | 36·5 | 33·4 | 0·054 | 0·065 | 0·060 | |
| | " " | — | — | 0·416 | — | — | |
| 11.25 a.m. } 2.15 p.m. } | *Elephantorrhiza Burchellii* | 36·5 | 33·4 | 0·0008 | 0·000 | 0·0004 | |
| 11.30 a.m.. | *Urginea rigidifolia*... | 36·5 | 33·4 | 0·025 | 0·025 | 0·025 | |

TABLE 4.

*Course of a Wilting Experiment.*

*Digitaria eriantha* 3.—Wilting Experiment No. 1 (in small bottle).

| Date. | Day. | Daily Output *pro* 1 gr. Fresh Matter in gr. | Daily Output *pro* 100 cm.² Surface in gr. | Soil Moisture. | Maximal Temp. | Minimal Temp. | Lowest Air Moisture per cent. Saturation. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 21–22 February, 1924 | 1 | 7·71 | 14·32 | 15·1 | 30 | 12 | 31 | |
| 22–23 February, 1924 | 2 | 4·85 | 9·01 | | 31·5 | 13 | 15 | |
| 23–24 February, 1924 | 3 | 7·71 | 14·32 | | 35 | 14·5 | c. 25 | |
| 24–25 February, 1924 | 4 | 6·00 | 11·1 | | 35 | 18 | 35 | |
| 25–26 February, 1924 | 5 | 3·14 | 5·9 | | 30·5 | 15·5 | 18·5 | |
| 26–27 February, 1924 | 6 | 7·57 | 14·26 | | 35 | 17 | 24 | |
| 27–28 February, 1924 | 7 | 6·28 | 11·84 | 8·55 | 32 | 16·5 | 15 | Withered: put into moist atmosphere. |
| 28–29 February, 1924 | 8 | | | | | | | In moist atmosphere: recovered after 24 hrs. |
| 29 Feb.–1 March, 1924 | 9 | 3·71 | 6·99 | | 36 | 15 | 25 | |
| 1–2 March, 1924 | 10 | 5·57 | 10·48 | 6·7 | 33 | 20·5 | 25 | Withered; put in moist atmosphere. |
| 2–3 March, 1924 | 11 | | | | | | | In moist atmosphere; did not recover after 24 hrs. Permanently wilted. |

TABLE 4—(*continued*).

*Course of a Wilting Experiment*—(continued).

*Eragrostis* 2.—Wilting Experiment No. 2 (in big bottle).

| Date. | Day. | Daily Output of Water in gr. *pro* 100 cm.² Surface. | Soil Moisture. | Maximal Temp. | Minimal Temp. | Lowest Air Moisture per cent Saturation. | Remark.. |
|---|---|---|---|---|---|---|---|
| 25–26 September, 1924 | 1 | 9·37 | 9·48 | 24·4 | 11·1 | 21 | |
| 26–27 September, 1924 | 2 | 33·07 | | 25·7 | 8·5 | 20 | |
| 27–28 September, 1924 | 3 | 29·92 | | 22·9 | 7·8 | 19 | |
| 28–29 September, 1924 | 4 | 29·92 | | 26·8 | 16·7 | c. 20 | |
| 29–30 September, 1924 | 5 | 37·35 | | 28·3 | 6·8 | 15 | |
| 30 September–1 October, 1924 | 6 | 34·41 | | 29·4 | 11·9 | 23 | |
| 1–2 October, 1924 | 7 | 28·78 | | 25·7 | 11·8 | 12 | |
| 2–3 October, 1924 | 8 | 12·27 | 1·18 | 27·9 | 13·2 | 27 | Withered; put into moist atmosphere. |
| 3–4 October, 1924 | 9 | | | | | | In moist atmosphere; after 24 hrs recovered. |
| 4–5 October, 1924 | 10 | 6·96 | 0·45 | 30·5 | 14·9 | 22 | Again wilted; put into moist atmosphere. |
| 5–6 October, 1924 | 11 | | | | | | In moist atmosphere; not recovered after 24 hrs. |

TABLE 5.

*Record of Experiment No.* 39.

| Plant. | Daily Values of Transpiration in gr. — *Pro* 1 gr. Fresh Matter. | Daily Values of Transpiration in gr. — *Pro* 100 cm.² Surface. | Factor which Determines the Result. |
|---|---|---|---|
| ***Digitaria eriantha*—** | | | |
| 1 | 1·71 | 1·7 | Low soil moisture for the meteorological conditions; bad condition from beginning. |
| 2 | 13·4 | 37·7 | Soil moisture high enough; good condition. |
| 3 | 7·7 | 13·7 | Low soil moisture for the surrounding meteorological factors; has little effect; causes the wilting; high leaf-root coefficient. |
| 4 | 10·0 | 25·0 | High soil moisture; good condition. |
| ***Eragrostis superba*—** | | | |
| 1 | 4·6 | 10·0 | Good condition beginning of experiment; soil moisture causes wilting. |
| 2 | 6·3 | 11·7 | Good conditions; high soil moisture. |
| 3 | 1·7 | 5·2 | In bad condition since beginning; low soil moisture accelerates the wilting. |
| 4 | 5·9 | 22·3 | Good conditions; very low coefficient leaves: roots. It is striking that this plant transpires so much more than 2 calculated on surface. The values for fresh matter, however, do not differ very much. |

TABLE 5—(*continued*).

*Record of Experiment No.* 39—(continued).

| Plant. | Fresh Matter of Leaves in gr. | Surface of Leaves in cm.² | Absorptive roots in gr. | Coefficient Leaves: Roots. | Soil Moisture in per cent. | Remarks. |
|---|---|---|---|---|---|---|
| *Digitaria eriantha*— | | | | | | |
| 1 | 0·175 | 17·28 | 0·100 | 1·75 | 4·04 | Plant dry in the afternoon and grey-green; recovered slightly over night. In bad condition from beginning. |
| 2 | 0·590 | 20·54 | 0·260 | 2·26 | 9·14 | Very well. |
| 3 | 0·280 | 15·87 | 0·050 | 5·6 | 5·66 | Drooping in the afternoon; looking much better the next morning; only little drooping. In good condition at the beginning of the experiment. |
| 4 | 0·440 | 17·74 | 0·180 | 2·4 | 16·63 | Very good. |
| ***Eragrostis** superba*— | | | | | | |
| 1 | 0·245 | 8·87 | 0·040 | 6·12 | 4·78 | Leaves soft, but one rolled, two folded; looking the next morning better than in the afternoon. Good condition in the beginning of experiment. |
| 2 | 0·165 | 8·87 | 0·150 | 1·1 | 13·91 | Looking well. |
| 3 | 0·400 | 13·07 | 0·530 | 0·75 | 4·6 | Leaves soft, but mostly rolled; a little better next morning. In bad condition from the beginning. |
| 4 | 0·665 | 17·27 | 1·250 | 0·53 | 9·47 | Very good. |

TABLE 6.

*Record of Experiment No. 39.—15th and 16th January, 1924.*

| Time. | Sun. | Wind. | Soil Temperature in ° C. | Air Temperature in ° C. above Plant. | Air Moisture in ° C. above Plant. |
|---|---|---|---|---|---|
| 15th January— | | | | | |
| 5.27 a.m. | — | 1 | 20·8 | 20·8 | 35 |
| 5·53 a.m. | Sunrise. | Light | since 5.15 a.m. | | |
| 6·12 a.m. | ⊙ | — | 20·6 | 20·6 | 38 |
| 7·15 a.m. | ⊙ | — | 22·7 | 22·7 | 29 |
| 8·20 a.m. | ⊙ | 3 | 22·5 | 25·4 | 23 |
| 9·17 a.m. | ⊙ | 3 | 25·0 | 27·8 | 19 |
| 10·16 a.m. | ⊙ | 3 | 30·0 | 31·6 | 17 |
| 11·00 a.m. | ⊙ | 3 | 33·0 | 33·2 | 16 |
| 12·13 p.m. | ⊙ | 1 | 38·5 | 34·8 | 13 |
| 12·53 p.m. | ⊙ | 3 | 41·5 | 34·7 | 12 |
| 1·56 p.m. | ⊙ | 2 | 43·0 | 36·8 | 11 |
| 2·58 p.m. | ⊙ | 1 | 44·0 | 36·4 | 10 |
| 3·55 p.m. | ⊙ | — | 43·5 | 35·2 | 11 |
| 4·59 p.m. | ⊙ | 1 | 41·0 | 36·2 | 11 |
| 6·00 p.m. | ⊙ | 1 | 37·0 | 33·5 | 10 |
| 7·02 p.m. | ⊙ | — | 33·0 | 32·0 | 13 |
| 7·35 p.m. | Sunset. | | | | |
| 8·00 p.m. | — | — | 28·5 | 28·5 | 15 |
| 9·00 p.m. | — | — | 26·0 | 27·3 | 19 |
| 9·55 p.m. | — | — | 24·5 | 24·5 | 21 |
| 11·00 p.m. | — | — | 21·6 | 21·5 | 33 |
| 11·56 p.m. | — | — | 20·0 | 21·0 | 28 |
| 16th January— | | | | | |
| 0·58 a.m. | — | — | 18·2 | 20·8 | 28 |
| 2·15 a.m. | — | — | 17·0 | 19·8 | 30 |
| 2·57 a.m. | — | — | 16·3 | 17·4 | 35 |
| 3·52 a.m. | — | — | 15·7 | 19·6 | 26 |
| 4·50 a.m. | — | — | 15·0 | 18·4 | 28 |
| 5·00 a.m. | Dawn | | | | |

TABLE 6B.

*Record of Experiment No. 39. 15th and 16th January, 1924.*

| Digitaria 1. Time. | Hourly Transpiration in gr. *pro* 1 gr. Fresh Matter. | Hourly Transpiration *pro* 100 cm.$^2$ Surface, in gr. | Digitaria 2. Time. | Hourly Transpiration *pro* 1 gr. Fresh Matter in gr. | Hourly Transpiration *pro* 100 cm.$^2$ Surface, in gr. | Digitaria 3. Time. | Hourly Transpiration in gr. *pro* 1 gr. Fresh Matter. | Hourly Transpiration in gr. *pro* 100 cm.$^2$ Surface. |
|---|---|---|---|---|---|---|---|---|
| 15th January. 4.59 a.m.–5.46 a.m. | 0·0 | 0·0 | 15th January. 5.05 a.m.– 5.49 a.m. | 0·117 | 0·337 | 15th January. 5.11 a.m.– 5.43 a.m. | 0·150 | 0·264 |
| 5.46 a.m.–6.42 a.m. | 0·0 | 0·0 | 5.49 a.m.– 6.44 a.m. | 0·184 | 0·531 | 5.43 a.m.– 6.49 a.m. | 0·457 | 0·806 |
| 6.42 a.m.–7.42 a.m. | 0·0 | 0·0 | 6.44 a.m.– 7.48 a.m. | 0·506 | 1·456 | 6.49 a.m.– 7.53 a.m. | 0·632 | 1·116 |
| 7.42 a.m.– 8.42 a.m. | 0·0 | 0·0 | 7.48 a.m.– 8.46 a.m. | 0·681 | 1·961 | 7.53 a.m.– 8.51 a.m. | 0·442 | 0·781 |
| 8.42 a.m.– 9.42 a.m. | 0·114 | 0·115 | 8.46 a.m.– 9.46 a.m. | 0·830 | 2·386 | 8.51 a.m.– 9.51 a.m. | 0·642 | 1·134 |
| 9.42 a.m.–10.30 a.m. | 0·0 | 0·0 | 9.46 a.m.–10.35 a.m. | 1·418 | 4·075 | 9.51 a.m.–10.38 a.m. | 0·635 | 0·122 |
| 10.30 a.m.–11.35 a.m. | 0·314 | 0·318 | 10.35 a.m.–11.39 a.m. | 1·456 | 4·182 | 10.38 a.m.–11.43 a.m. | 0·857 | 1·512 |
| 11.35 a.m.–12.31 p.m. | 0·302 | 0·306 | 11.39 a.m.–12.34 p.m. | 1·405 | 4·036 | 11.43 a.m.–12.37 p.m. | 0·714 | 1·260 |
| 12.31 p.m.– 1.34 p.m. | 0·0 | 0·0 | 12.34 p.m.– 1.36 p.m. | 1·642 | 4·719 | 12.37 p.m.– 1.38 p.m. | 0·714 | 1·260 |
| 1.34 p.m.– 2.34 p.m. | 0·228 | 0·230 | 1.36 p.m.– 2.37 p.m. | 1·317 | 3·792 | 1.38 p.m.– 2.40 p.m. | 0·485 | 0·857 |
| 2.34 p.m.– 3.34 p.m. | 0·0 | 0·0 | 2.37 p.m.– 3.38 p.m. | 1·334 | 3·831 | 2.40 p.m.– 3.41 p.m. | 0·464 | 0·819 |
| 3.34 p.m.– 4.34 p.m. | 0·114 | 0·115 | 3.38 p.m.– 4.38 p.m. | 1·068 | 3·067 | 3.41 p.m.– 4.42 p.m. | 0·464 | 0·819 |
| 4.35 p,m.– 5.36 p.m. | 0·114 | 0·115 | 4.38 p.m.– 5.39 p.m. | 0·833 | 2·288 | 4.42 p.m.– 5.42 p.m. | 0·250 | 0·441 |
| 5.36 p.m.– 6.36 p.m. | 0·0 | 0·0 | 5.39 p.m.– 6.39 p.m. | 0·644 | 1·850 | 5.42 p.m.– 6.43 p.m. | 0·107 | 0·189 |
| 6.36 p.m.– 7.35 p.m. | 0·0 | 0·0 | 6.39 p.m.– 7.38 p.m. | 0·135 | 0·389 | 6.43 p.m.– 7.41 p.m. | 0·442 | 0.781 |
| 7.35 p.m.– 8.30 p.m. | 0·0 | 0·0 | 7.38 p.m.– 8.35 p.m. | 0·0 | 0·0 | 7.41 p.m.– 8.38 p.m. | 0·107 | 0·189 |
| 8.30 p.m.– 9.33 p.m. | 0·188 | 0·190 | 8.35 p.m.– 9.37 p.m. | 0·135 | 0·389 | 8.38 p.m.– 9.39 p.m. | 0·178 | 0·315 |
| 9.33 p.m.–10.34 p.m. | 0·0 | 0·0 | 9.37 p.m.–10.37 p.m. | 0·068 | 0·195 | 9.39 p.m.–10.39 p.m. | 0·071 | 0·126 |
| 10.34 p.m.–11.34 p.m. | + 0·114 | +0·115 | 10.37 p.m.–11.37 p.m. | 0·017 | 0·048 | 10.39 p.m.–11.39 p.m. | 0·036 | 0·063 |
| 16th January. 11.34 p.m.– 0.34 a.m. | 0·114 | 0·115 | 16th January. 11.37 p.m.– 0.37 a.m. | 0·034 | 0·096 | 16th January. 11.39 p.m.– 0.40 a.m. | 0·107 | 0·189 |
| 0.34 a.m.– 1.53 a.m. | 0·091 | 0·092 | 0.37 a.m.– 1.58 a.m. | 0·051 | 0·144 | 0.40 a.m.– 2.01 a.m. | 0·135 | 0·239 |
| 1.53 a.m.– 2.34 a.m. | 0·086 | 0·086 | 1.58 a.m.– 2.36 a.m. | 0·051 | 0·144 | 2.01 a.m.– 2.39 a.m. | 0·054 | 0·095 |
| 2.34 a.m.– 3.34 a.m. | 0·114 | 0·115 | 2.36 a.m.– 3.38 a.m. | 0·034 | 0·096 | 2.39 a.m.– 3.40 a.m. | 0·107 | 0·189 |
| 3.34 a.m.– 4.34 a.m. | 0·057 | 0·058 | 3.38 a.m.– 4.36 a.m. | 0·017 | 0·048 | 3.40 a.m.– 4.38 a.m. | 0·0 | 0·0 |

## Table 6c.

*Record of Experiment No. 39. 15th and 16th January, 1924.*

| Digitaria 4. | | | Eragrostis 1. | | | Eragrostis 2. | | |
|---|---|---|---|---|---|---|---|---|
| Time. | Hourly Transpiration *pro* 1 gr. Fresh Matter, in gr. | Hourly Transpiration *pro* 100 cm.² Surface, in gr. | Time. | Hourly. Transpiration *pro* 1 gr. Fresh Matter, in gr. | Hourly Transpiration *pro* 100 cm.² Surface, in gr. | Time. | Hourly Transpiration *pro* 1 gr. Fresh Matter, in gr. | Hourly Transpiration *pro* 100 cm.² Surface, in gr. |
| 15th January. 5.15 a.m.– 5.56 a.m.... | 0·170 | 0·422 | 15th January. 5.18 a.m.– 5·58 a.m.... | 0·0 | 0·0 | 15th January. 5.23 a.m.– 6·00 a.m.... | 0·454 | 0·842 |
| 5.56. a.m.– 6.52 a.m... | 0·340 | 0·844 | 5.58 a.m.– 6.54 a.m.... | 0·432 | 1·190 | 6.00 a.m.– 6.57 a.m.... | 0·0 | 0·0 |
| 6.52 a.m.– 7.58 a.m.... | 0·722 | 1·793 | 6.54 a.m.– 8.04 a.m.... | 0·526 | 1·448 | 6.57 a.m.– 8.07 a.m.... | 0·442 | 0·819 |
| 7.58 a.m.– 8.56 a.m.... | 0·704 | 1·747 | 8.04 a.m.– 9.02 a.m.... | 0·334 | 0·920 | 8.07 a.m.– 9.06 a.m.... | 0·424 | 0·785 |
| 8.56 a.m.– 9.55 a.m.... | 0·863 | 2·142 | 9.02 a.m.–10.02 a.m.... | 0·204 | 0·561 | 9.06 a.m.–10.06 a.m.... | 0·545 | 1·010 |
| 9.55 a.m.–10.41 a.m.... | 1·244 | 3·083 | 10.02 a.m.–10.45 a m.... | 0·567 | 1·561 | 10.06 a.m.–10.48 a.m.... | 0·860 | 1·595 |
| 10.41 a.m.–11.54 a.m.... | 0·838 | 2·080 | 10.45 a.m.–11.59 a.m.... | 0·277 | 0·763 | 10.48 a.m.–12.03 p.m.... | 0·775 | 1·438 |
| 11.54 a.m.–12.40 p.m.... | 0·879 | 2·182 | 11.59 a.m.–12.43 p.m.... | 0·489 | 1·347 | 12.03 p.m.–12.45 p.m.... | 0·860 | 1·595 |
| 12.40 p.m.– 1.40 p.m.... | 0·681 | 1·688 | 12.43 p.m.– 1.44 p.m.... | 0·367 | 0·936 | 12.45 p.m.– 1.47 p.m.... | 0·587 | 1·089 |
| 1.40 p.m.– 2.43 p.m.... | 0·820 | 2·035 | 1.44 p.m.– 2.46 p.m.... | 0·318 | 0·875 | 1.47 p.m.– 2.49 p.m.... | 0·642 | 1·190 |
| 2.43 p.m.– 3.44 p.m.... | 0·545 | 1·353 | 2.46 p.m.– 3.47 p.m.... | 0·244 | 0·624 | 2.49 p.m.– 3.50 p.m.... | 0·363 | 0·707 |
| 3.44 p.m.– 4.48 p m.... | 1·020 | 2·526 | 3.47 p.m.– 4.51 p.m.... | 0·228 | 0·628 | 3.50 p.m.– 4.54 p.m.... | 0·169 | 0·314 |
| 4.48 p.m.– 5.46 p.m.... | 0·397 | 0·986 | 4.51 p.m.– 5.49 p.m.... | 0·041 | 0·112 | 4.54 p.m.– 5.54 p.m.... | 0·182 | 0·354 |
| 5.46 p.m.– 6.47 p.m.... | 0 534 | 1·297 | 5.49 p.m.– 6.49 p.m.... | 0·163 | 0·449 | 5.54 p.m.– 6.53 p.m.... | 0·121 | 0·236 |
| 6.47 p.m.– 7.44 p.m.... | 0·118 | 0·293 | 6.49 p.m.– 7.47 p.m.... | 0·081 | 0·225 | 6.53 p.m.– 7.49 p.m.... | 0·121 | 0·236 |
| 7.44 p.m.– 8.40 p.m.... | 0·121 | 0·298 | 7.47 p.m.– 8.43 p.m.... | 0·041 | 0·112 | 7.49 p.m.– 8.46 p.m.... | 0·0 | 0·0 |
| 8.40 p.m.– 9.43 p.m.... | 0·0 | 0·0 | 8.43 p.m.– 9.44 p.m.... | 0·081 | 0·225 | 8.46 p.m.– 9.48 p.m.... | 0·061 | 0·118 |
| 9.43 p.m.–10.43 p.m.... | 0·068 | 0·169 | 9.44 p.m.–10.45 p.m.... | 0·0 | 0·0 | 9.48 p.m.–10.48 p.m.... | +0·121 | +0·236 |
| 10.43 p.m.–11.42 p.m.... | +0·023 | +0·056 | 10.45 p.m.–11.45 p.m.... | +0·081 | +0·225 | 10.48 p.m.–11.48 p.m.... | 0·0 | 0·0 |
| 16th January. 11.42 p.m.– 0.44 a.m.... | 0·091 | 0·225 | 16th January. 11.45 p.m.– 0.47 a.m.... | 0·122 | 0·337 | 16th January. 11.48 p.m.– 0.49 a.m.... | 0·061 | 0·118 |
| 0.44 a.m.– 2.04 a.m.... | 0·086 | 0·214 | 0.47 a.m.– 2.06 a.m.... | 0·122 | 0·337 | 0.49 a.m.– 2.08 a.m.... | 0·0 | 0·0 |
| 2.04 a.m.– 2.42 a.m.... | 0·0 | 0·0 | 2.06 a.m.– 2.46 a.m.... | +0·061 | +0·169 | 2.08 a.m.– 2.48 a.m.... | 0·061 | 0·118 |
| 2.42 a.m.– 3.42 a.m.... | 0·091 | 0·225 | 2.46 a.m.– 3.45 a.m.... | 0·041 | 0·112 | 2.48 a.m.– 3.48 a.m.... | 0·061 | 0·118 |
| 3.42 a.m.– 4.42 a.m.... | +0·023 | +0·056 | 3.45 a.m.– 4.45 a.m.... | 0·0 | 0·0 | 3.48 a.m.– 4.47 a.m.... | +0·061 | +0·118 |

TABLE 6D.

*Record of Experiment No. 39. 15th and 16th January, 1924.*

| Eragrostis 3. | | | Eragrostis 4. | | |
|---|---|---|---|---|---|
| Time. | Hourly Transpiration *pro* 1 gr. Fresh Matter, in gr. | Hourly Transpiration *pro* 100 cm.² Surface, in gr. | Time. | Hourly Transpiration *pro* 1 gr. Fresh Matter, in gr. | Hourly Transpiration *pro* 100 cm.² Surface, in gr. |
| 15th January. 4.54 a.m.– 6.05 a.m.... | 0·0 | 0·0 | 15th January. 4.49 a.m.– 6·07 a.m.... | 0·0 | 0·0 |
| 6.05 a.m.– 7.01 a.m.... | 0·052 | 0·160 | 6.07 a.m.– 7.04 a.m.... | 0·109 | 0·422 |
| 7.01 a.m.– 8.11 a.m.... | 0·0 | 0·0 | 7.04 a.m.– 8.14 a.m.... | 0·297 | 1·442 |
| 8.11 a.m.– 9.10 a.m.... | 0·0 | 0·0 | 8.14 a.m.– 9.13 a.m.... | 0·315 | 1·216 |
| 9.10 a.m.–10.10 a.m.... | 0·075 | 0·229 | 9.13 a.m.–10.14 a.m.... | 0·526 | 2·027 |
| 10.10 a.m.–10.52 a.m.... | 0·212 | 0·650 | 10.14 a.m.–10.58 a.m.... | 0·421 | 1·621 |
| 10.52 a.m.–12.06 p.m.... | 0·165 | 0·505 | 10.58 a.m.–12.09 p.m.... | 0·648 | 2·495 |
| 12.06 p.m.–12.48 p.m.... | 0·173 | 0·543 | 12.09 p.m.–12.51 p.m.... | 0·601 | 2·316 |
| 12.48 p.m.– 1.50 p.m.... | 0·150 | 0·459 | 12.51 p.m.– 1.54 p.m.... | 0·556 | 2·142 |
| 1.50 p.m.– 2.50 p.m.... | 0·100 | 0·306 | 1.54 p.m.– 2.55 p.m.... | 0·511 | 1·964 |
| 2.50 p.m.– 3.53 p.m.... | 0·100 | 0·306 | 2.55 p.m.– 3.56 p.m.... | 0·511 | 1·964 |
| 3.53 p.m.– 4.56 p.m.... | 0·150 | 0·459 | 3.56 p.m.– 4.59 p.m.... | 0·514 | 1·980 |
| 4.56 p.m.– 5.56 p.m.... | 0·100 | 0·306 | 4.59 p.m.– 5.59 p.m.... | 0·406 | 1·563 |
| 5.56 p.m.– 6.58 p.m.... | 0·047 | 0·145 | 5.59 p.m.– 7.00 p.m.... | 0·255 | 0·984 |
| 6.58 p.m.– 7.53 p.m.... | 0·137 | 0·420 | 7.00 p.m.– 7.56 p.m.... | 0·079 | 0·309 |
| 7.53 p.m.– 8.49 p.m.... | 0·0 | 0·0 | 7.56 p.m.– 8.51 p.m.... | 0·048 | 0·185 |
| 8.49 p.m.– 9.50 p.m.... | 0·0 | 0·0 | 8.51 p.m.– 9.52 p.m.... | 0·0 | 0·0 |
| 9.50 p.m.–10.53 p.m.... | +0·075 | +0·229 | 9.52 p.m.–10.55 p.m.... | 0·0 | 0·0 |
| 10.53 p.m.–11.50 p.m.... | 0·025 | 0·076 | 10.55 p.m.–11.52 p.m.... | 0·0 | 0·0 |
| 16th January. 11.50 p.m.– 0.52 a.m.... | 0·075 | 0·229 | 16th January. 11.52 p.m.– 0.55 a.m.... | 0·042 | 0·162 |
| 0.52 a.m.– 2.10 a.m.... | 0·062 | 0·191 | 0.55 a.m.– 2.12 a.m.... | 0·037 | 0·144 |
| 2.10 a.m.– 2.50 a.m.... | 0·0 | 0·0 | 2.12 a.m.– 2.53 a.m.... | 0·0 | 0·0 |
| 2.50 a.m.– 3.51 a.m.... | 0·0 | 0·0 | 2.53 a.m.– 3.53 a.m.... | 0·030 | 0·115 |
| 3.51 a.m.– 4.50 a.m.... | 0·0 | 0·0 | 3.53 a.m.– 4.51 a.m.... | 0·0 | 0·0 |

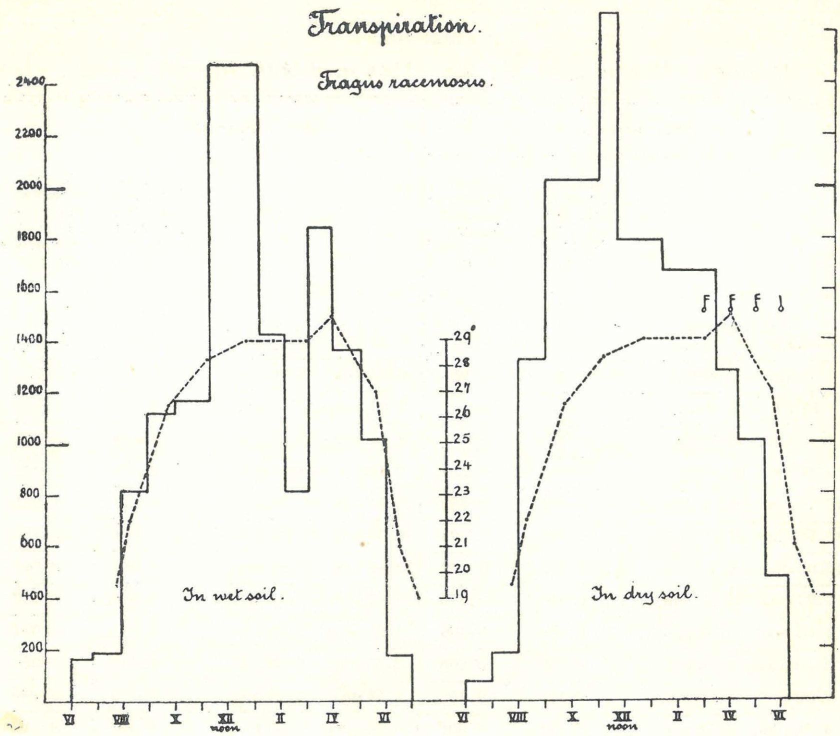



CHART 1.—Transpiration of *Tragus racemosus* in dry and wet soil, 28th March, 1923
No adaption to dry soil can be seen.

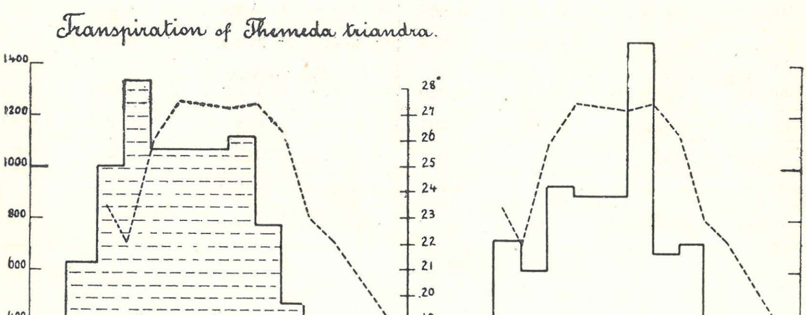



CHART 2.—Transpiration of *Themeda triandra* in dry and wet soil 15th–16th April, 1923. No adaption to dry soil can be seen, although the plant in dry soil has rolled leaves.

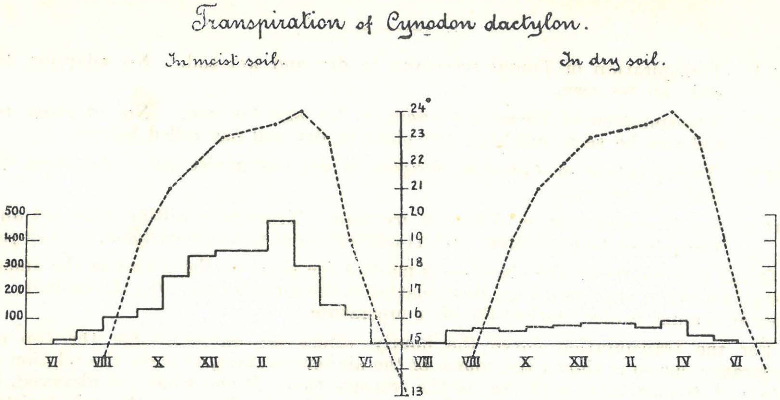



CHART 3.—Transpiration of *Cynodon dactylon* in moist and dry soil, 26th April, 1923. Adaption to dry soil can be seen.

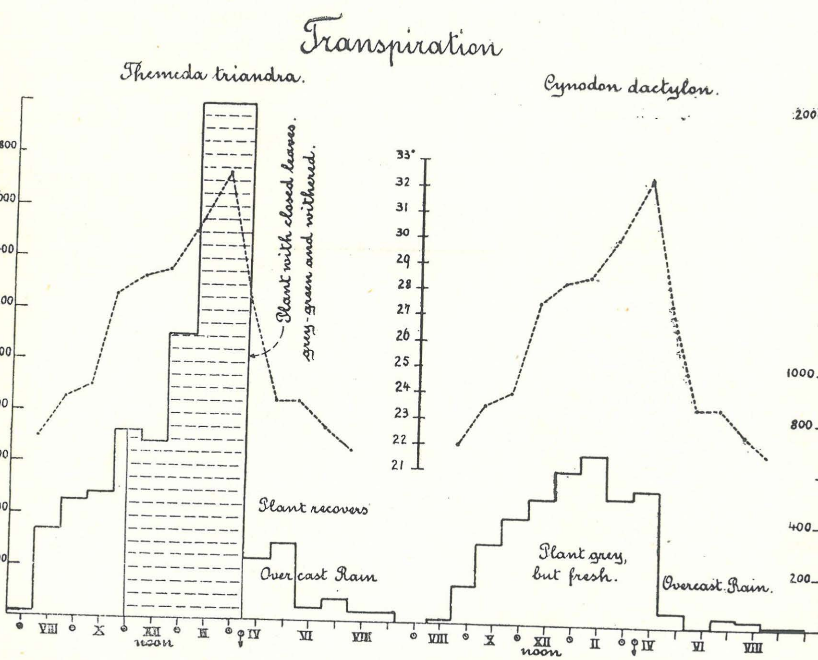



CHART 4.—Transpiration of *Themeda triandra* and *Cynodon dactylon*, 13th February, 1923. Temporary wilting does not diminish the rate of transpiration (*Themeda*). *Cynodon* for comparison under the same conditions.

## EXPLANATION OF CHARTS Nos. 1 to 4..

*Chart* 1.—Transpiration of *Tragus racemosus* in dry and wet soil. No adaption to dry soil can be seen.

*Chart* 2.—Transpiration of *Themeda triandra* in dry and wet soil. No adaption to dry soil can be seen, although the plant in dry soil has rolled leaves.

*Chart* 3.—Transpiration of *Cynodon dactylon* in dry and moist soil. Adaption to dry soil can be seen.

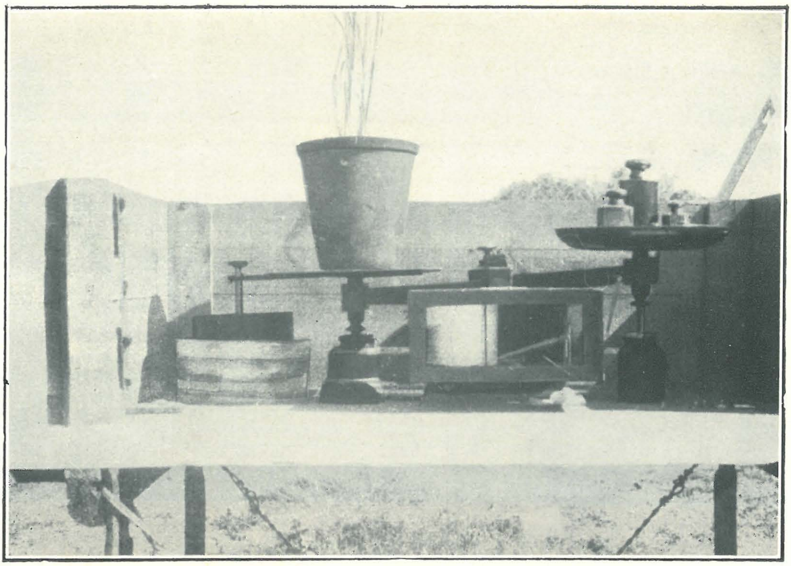
*Chart* 4.—(*a*) Transpiration of *Themeda triandra.* Temporary wilting does not diminish the rate of transpiration. (*b*) Transpiration of *Cynodon dactylon,* for comparison.

On all four charts on the abscissae is marked the time, on the ordinates the amount of water given out in mgr. pro. 1 gr. fresh matter of the grass-leaves. On the ordinates above the water-amount is also marked the air temperature.

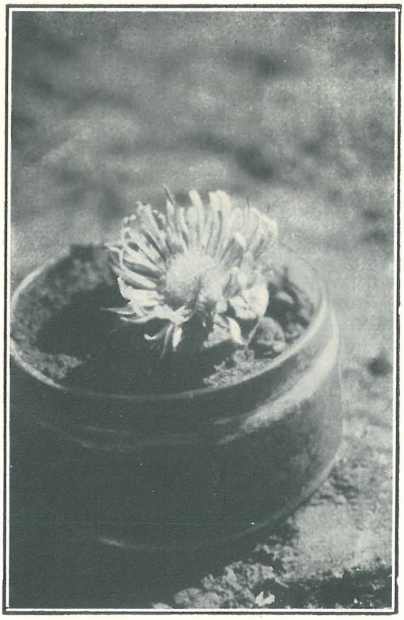
For the transpiration curve the hourly values are entered. On the top of the transpiration curve is shown the course of the air temperature, to show the relation of the position of its maximum with that of the transpiration. When wind was observed, it was entered as the degrees of the Beaufort scale. The condition of the soil moisture is written below the curves.

With the exception of *Themeda* and *Cynodon,* all determinations were made in full sunshine. On Chart 4, therefore, the time of the sunshine is marked with the usual meteorological sign for sun, ⨀; the disappearing sun is marked with an arrow, ⍖.

The shaded parts of the transpiration curves are the parts during which time the plant was withered.



Richard balance-box open to show the balance.



*Mesembryanthemum Lesliei.*