Studies on the Method for Measuring Amounts of Evapotranspiration

1. A method by measuring humidity using transpiration chambers*.

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Amounts of evapotranspiration (ET) have been measured so far by the decrease of weight of pots or by the decrease of water-depth of evapotranspirometers on which crops were cultivated. Soil condition and the growth of crops in such cases differs usually from that in the natural fields. It is not appropriate to determine accurate water losses from agricultural lands by the above methods. Some meteorological ways to measure ET of crops in fields as it stands have advanced in several foreign countries. But the direct application of those apparatus is not convenient, because of its high cost, need of special technicians, as well as of the changeable weather and complicated topography and pedological condition in the fields. Accordingly we think that there should be some different ways and approaches to measure the accurate water losses from farm lands in Japan.

Authors are going to report a new, simple and practical method using a transpiration chamber (T-chamber) in which ventilation was carried out by a blower and measuring humidity both at the entrance and exit.

1. Formulae and apparatus for measurment.

Amounts of ET is indicated by

$$ET = (X_2 - X_1) Q \dots \dots \dots (1)$$

where X_1, X_2 ...absolute humidity(g/m³) of the air at the entrance and exit of T-chamber.

Q quantity of air-flow (m³).

X_1, X_2 are calculated by the following formula.

$$X_{1,2} = \frac{0.622 \times 1.293 \times 10}{1 + 0.00367 t_{1,2}} \times \frac{e_{1,2}}{760} = \frac{1.0582 e_{1,2}}{1 + 0.00367 t_{1,2}} \dots \dots \dots (2)$$

And $e_{1,2}$ is calculated by

$$e_{1,2} = ew_{1,2} - 4/3A (t_{1,2} - tw_{1,2}) P/755 \dots \dots \dots (3)$$

where $t_{1,2}$...dry-bulb temperature at the entrance and exit (°C).

$tw_{1,2}$...wet-bulb temperature at the entrance and exit (°C).

$e_{1,2}$...vapour pressure at the entrance and exit. (mm, Hg)

$ew_{1,2}$...saturated vapour pressure at the wet-bulb temperature for the entrance and exit. (mm, Hg)

P ...atmospheric pressure (mm, Hg).

$$P = P_0 + 1/2 \rho U^2$$

Fig. 1 Apparatus

A...a constant provided by the air flow velocity.

P_0 (static pressure inside the tube) is considered to be nearly the same to P . The change of e due to the change of P is very small, so the P is normally estimated as 1 atmospheric pressure in the formula (3). ET is calculated by measuring dry-bulb, wet-bulb temperature and Q .

a. Transpiration chamber and its attachments.

A chamber applied for paddies in upland fields was made by chloride vinyl plate (30cm in diameter, 120cm in height), as shown in Fig. 1. The other for ears and leaves was same shape as the above, but rather small in size (15cm in diameter, 60 cm in height). An entrance and exit tube of air flow (3 cm in diameter) was set up at the upper and the lower part respectively. A distributor and a rectifier were settled inside the T-chamber in order to smooth the air-flow. An entrance tube was connected with an absorption pipe through a supporter of thermosensitive tips to avoid the abrupt change of open air. An exit tube was connected with an Orifice flow-meter through a supporter of thermosensitive tips. When we are going to measure in actual fields, a grooved ring was set into fields beforehand, and T-chamber was settled in the groove of the ring. Those folding parts were shut with vinyl tapes and covering

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of soil-heaping to make the system air-tight. Also in use of a small T-chamber thin vinyl film skirts fastened tightly the base of leaves or ears.

b. A blower and flow-meter.

A blower with the static pressure (450 mm Aq) and the Q (1 m³/min.) was used in the condition of air-absorption for ventilation. Its motor was 1/2HP, 9500 r. p. m. An Orifice-meter as a flow-meter could adjust the Q in the range of 20~250 l/min. Q was decided by these factors; ET, air condition, size of T-chamber and accuracy of thermometer.

c. Instruments for measuring temperature and humidity.

An electric thermometer recorder with six thermosensitive tips made by thermistor, 10~40°C in the measure range and 0.1°C in the accuracy was settled. The tip was 25 mm in length and 1.5 mm in diameter. A pair of dry and wet bulb was inserted into the entrance tube and the other pair into the exit tube of the chamber. Each elements was automatically recorded with 15 second interval.

2. Results of the test.

a. Comparison between results obtained by T-chamber method and these by weighing method.

A water-pan or rice plants on a pot was kept inside the T-chamber, and both the decrease of weight and the ET was measured at the same time for 90 or 120 minutes. The results were compared by the ratio (ET by T-chamber method/ET by weighing method·%) and showed the value of 90 % average in case of the large chamber, and 98 % in the small chamber. Attaching a rectifier, a distributor and an absorption pipe improved the fitness up to 95% on the large T-chamber, probably because of smoothed air-flow and of stabilization of open air. However, the ratio in the improved large T-chamber was still a little lower than that in the small T-chamber. It is presumably considered that the even distribution of air-flow was

Fig. 2 Comparison between T-chamber method and weighing method.

realized more easily in the small T-chamber than in the large one as far as our experiments concerned. Differences of ratio between weighing method and T-chamber method will be probably buried by the recording of shorter interval and the elevation of accuracy of thermistor.

b. Results of measurement in fields.

Measurement by T-chamber method was carried out in fields from 6:35 p.m. Aug. 10th in 1959 to the same time of Aug. 11th, on a fine day. On the other hand, rice plants cultivated on a pot was weighed at the same time and periods. The ET calculated at every thirty minutes and daily variations were shown in Fig. 3. 5 hills of "Yachikogane" (paddy with 32 tillers) and "Norin No. 12" (upland paddy with 36 tillers) in fields were tested by T-chamber method with the Q of 150 l/min. A hill of "Yachikogane" (paddy with 32 tillers) cultivated in a pot was tested by weighing method. Nearly the same tendency of the daily variation was observed in both cases, namely more in the day and less in the night. But the daily variation by the T-chamber method showed rather smooth change because of the definite velocity of air-flow, while rather abrupt change was observed on a pot by weighing method because of the influence due to the changeable open air. Temperature and humidity inside the T-chamber were 2.5°C and 20 % higher than those of open air in the day. Condensation of dew on the inner surface of the chamber was only seen in

Fig. 3 Daily variations of evapotranspiration

Fig. 4 Daily variations of transpiration of ears and flag leaves

a case when relative humidity rose up more than 90% in the night. So it will be necessary the increase of the air-flow.

c. Results of measurement by the small T-chamber.

Amounts of transpiration of ears and leaves were quantitatively measured by the small

T-chamber with the 45 l/min. air-flow and were calculated at every thirty minutes as shown in Fig. 4. The amounts of transpiration and daily variation fairly coincided with those which were presumed from the data of a whole crop.

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〔和 文 摘 要〕

蒸発散量測定法に関する研究

1. 蒸散室を使用し湿度測定による法*

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圃場に栽培中の作物について蒸発散量を測定しようとして, 塩化ビニール製円筒型蒸散室を用いこれに通気を行い, その出入口に於てサーミスター高感度電気温度計で温, 湿度を測定し, 出入口に於ける湿度差より蒸発散量を測定する方法を考案した。

現在, 重量法に比し本法による場合は5~2%低く表出されるので更に改良の余地が認められるが, 重量法と同じような日変化を示し, 圃場に生育中の作物について測定が可能ばかりでなく葉, 穂, 果実等植物の器官別にも蒸散量が測定できる。

本研究は当场栽培第二部今井富蔵部長の構想と援助により, 実施にあたっては農業技術研究所気象科三原義秋科長並に名古屋工業大学山田治夫教授の指導を受けた。猶, 当场池田利良場長より終始御鞭達を戴き論文の作成にあたっては御懇篤なる御指導と御校閲を戴いた。それぞれ記して感謝の意を表す。また多数の先輩, 同僚より示唆を戴いたことを深謝する次第である。