Automatic Irrigation System on Mulberry Fields

By Toshio NAOI

Moriculture Division, Sericultural Experiment Station

The yearly precipitation of Japan, though variable by districts, is fairly abundant with a mean value of about 1,600 mm. The precipitation, however, is not much in July and August, during which season mulberry plants often suffer from drought causing a decrease in yield and food value of leaves, which results in reduced yields of silkworm cocoon.

To prevent drought damage of mulberry trees, several countermeasures such as abundant application of organic matter and mulching treatment had been practiced, but irrigation was most effective. Irrigation has been introduced in districts of habitual drought damage and its effectiveness has been proved experimentally.

Method of irrigation is determined based on topography of fields, kinds of crops and an objective of irrigation. The water sprinkling method with sprinklers is most widely utilized for mulberry fields.

In many cases, sprinklers are moved from place to place in fields for irrigation. This system is advantageous in small fields, but is laborious for large fields.

The stationary irrigation system is far labor-saving but much expensive compared with the moving system. Therefore, full examinations are needed to obtain actual profit of irrigation. In this respect, an automatic system of irrigation can reduce labor and increase labor productivity. In any case, however, the most effective irrigation method is to give just required amount of water at an optimum stage.

Some kinds of automatic irrigators have been commercialized already. One of them is designed to irrigate based on soil moisture measurement. Another one is based on estimated daily water consumption and irrigation interval that were obtained from the past examples of measurement. These methods, however, have defects such as that the relation between soil moisture variation and water consumption should be determined beforehand or water consumption cannot be estimated from irrigation intervals because evapotranspiration of mulberry fields varies with climatic conditions.

Results of studies carried out since 1965 by the author are described briefly.

Characteristics of evapotranspiration in mulberry fields

For the planning of irrigation, optimum time and amount of irrigation must be determined by considering characteristics of evapotranspiration of crops and conditions of soils and climate.

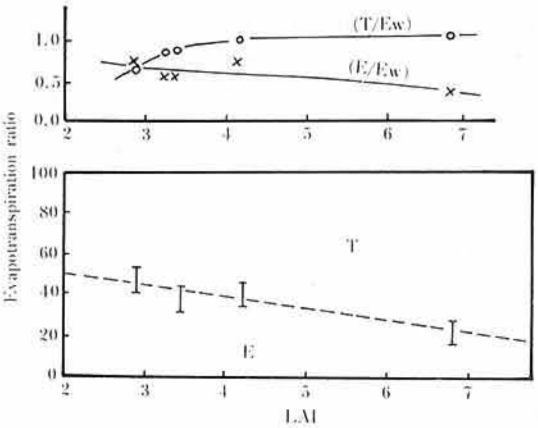
The author determined evapotranspiration (ET) of mulberry fields by using the chamber method devised by Kato et al. and studied relations to leaf area index (LAI) and climatic factors.

Fig. 1 shows the relation between LAI and evapotranspiration ratio (ET/EW). It is recognized that the ET-ratio increased with LAI until LAI reached a value of 4, and became nearly constant. The ratio of transpiration (T) to the evapotranspiration also increased with an increase of LAI. The evapotranspiration of mulberry field ranged from 1 to 1.5 times amount of evaporation from an

Table 1. Correlation coefficients between transpiration, evaporation and climatic factors (1971)

	Day time		Night time	
	Transpiration	Evaporation	Transpiration	Evaporation
	n	n	n	n
Temperature	0.727 (26)	0.648 (20)	0.713 (6)	0.542 (3)
Relative humidity	−0.659 (26)	−0.566 (20)	−0.664 (5)	−0.456 (3)
Saturation deficit	0.809 (26)	0.774 (20)	0.860 (5)	0.879 (3)
Solar radiation	0.758 (21)	0.520 (17)	— —	— —

Note: Day time: 6.00 AM–6.00 PM
Night time: 6.00 AM–6.00 AM
n: Number of days at which measurements were made



T : Transpiration E : Evaporation
Ew : Evaporation from free water surface (evaporator)

Fig. 1. Relation between evapotranspiration ratio and leaf area index (LAI)

evaporator (Ew).

Table 1 shows correlation coefficient between transpiration, evaporation and climatic factors (solar radiation, temperature, relative humidity, saturation deficit) of mulberry fields. It is apparent that these four climatic factors have high correlations with transpiration of mulberry fields and evaporation from soil surface. These results indicates that evapotranspiration of mulberry fields varies with climatic factors and hence amount of water to be irrigated can not be determined logically on the basis of duration of irrigation intervals.

Amount of water irrigated and leaf yields

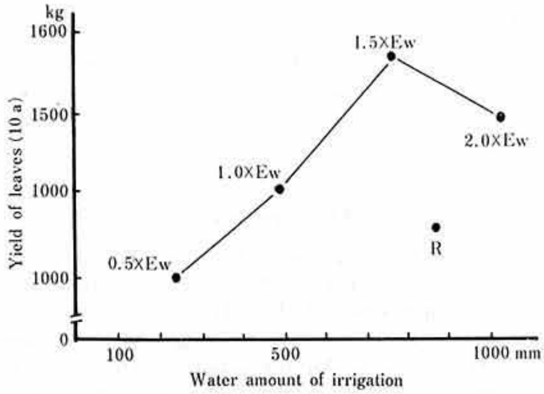
Evapotranspiration of mulberry fields was determined as to be 1.0 to 1.5 times of evaporation (Ew), as presented above. However, there is still a question whether that amount of water would be sufficient enough or not to obtain high yields of leaves. Therefore, the following experiment was conducted in 1969 and 1970.

On the basis of the evaporation in climatological site (Ew), experiments were conducted in 1969 and 1970, with the irrigations of 0.5, 1.0, 1.5, 2.0×Ew and rainfall depth. Then the variation of soil moisture and the yield of leaves were examined. In these experiments, the influence of natural rainfall on the test fields was eliminated with a large vinyl roof which can cover the fields moving automatically when it rains.

Under this condition, different irrigation treatments, 0.5×Ew, 1.0×Ew, 1.5×Ew and 2.0×Ew, were given. In an additional plot (referred to plot R), an irrigation simulated to rainfalls during the period of experiment was given. Soil moisture was determined everyday at different depth of soil using tensiometers. It was observed that pF value of soil increased in 0.5×Ew and R plots.

Fig. 2 shows the relation between the amount of water irrigated and leaf yields. The yields increased with increasing amount of water until it reached 1.5×Ew and then decreased. Irrigation simulated to rainfall resulted in less yields than 1.0×Ew in spite of more water was irrigated than 1.5×Ew.

Thus, it was proved experimentally that the optimum water amount for irrigation ranges from 1.0 to 1.5 times amount of evaporation



Note: Ew: Evaporation amount
R: Irrigation simulated to actual rainfall
Period of experiment:
May to October, 1970–1971

Fig. 2. Relation between the amount of water irrigated and leaf yields

(Ew) from an evaporator. However, this is a result obtained under an experimental condition without rainfalls. In practicing irrigation, supply of water by rainfalls must be taken into consideration.

Automatic control of irrigation

The author deviced an apparatus by which supply of irrigation water is controlled by an electric reading of changes of water level in an evaporator. The principle is based on the fact that optimum water for irrigation is 1–1.5 times amount of evaporation from an evaporator, which is expressed by the changes of water level in it.

Fig. 3 shows the apparatus constructed in 1970. It is consisted of an evaporator, rain-gauge, electrodes for reading water level, electromagnetic valves for watering, connecting cable between electrodes and electromagnetic valves, etc.

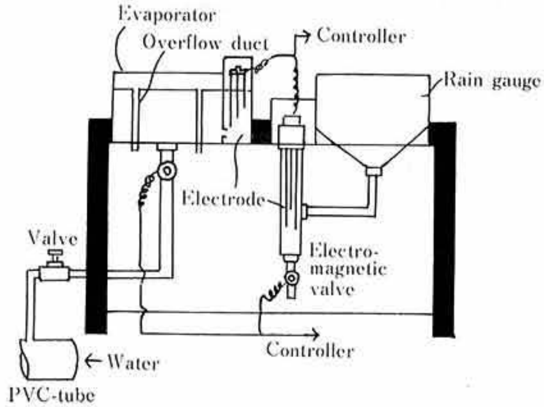


Fig. 3. Appartus for automatic control of irrigation

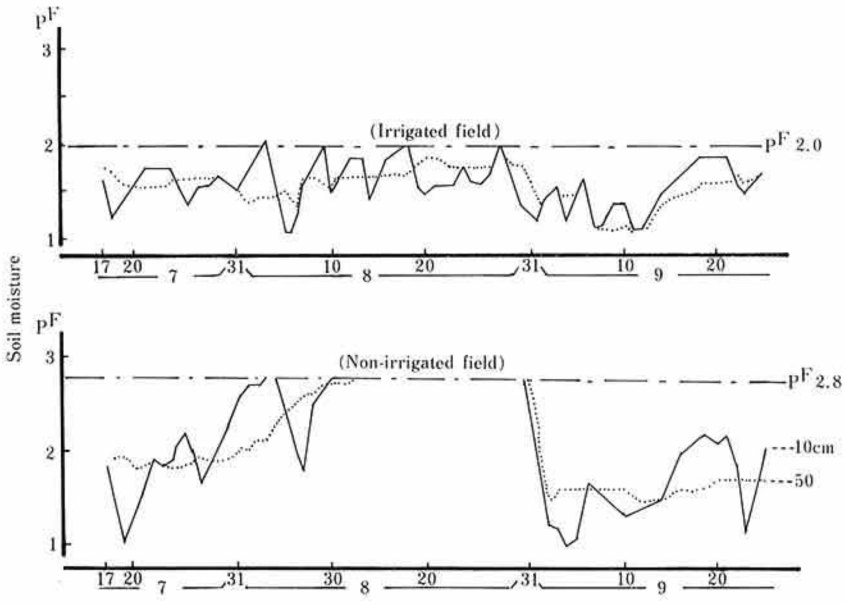


Fig. 4. Daily changes of soil moisture as expressed by pF

The apparatus is installed at sunny, dry place. After a heavy rainfall (about 30 mm) or irrigation, the evaporator is filled with water (naturally in case of rainfalls and through a water tube in case of irrigation).

Loss of water in an evaporator represents corresponding evapotranspiration of mulberry fields and the rise of water level caused by rainfall shows the water supplied to mulberry fields. Overflow of rain water from the evaporator corresponds to the runoff of rain water from mulberry fields. Thus, changes of water level of evaporator indicates the changes of soil moisture of mulberry fields.

The function of rain-gauge is to stop irrigation, when rain falls during the irrigation.

Practical usefulness of the apparatus was examined at the Experimental Mulberry Farm at Hino, Tokyo. As shown in Fig. 4, soil moisture of the irrigated field was kept less than 2 of pF throughout the growing period, while that of non-irrigated field showed high pF values during long spells of fine weather. The leaf yield of the irrigated field was more than 30% higher than that of the non-irrigated field.

It can be concluded that this automatic irrigation system is useful in controlling irrigation, in saving labor, and in increasing leaf yields.

References

1) Kato, I. & Kamota, F.: Measurement of evapotranspiration by chamber method and its application. *JARQ*, 4(1), 27–32 (1969).

2) Kato, I. et al.: Improving the field crop irrigation. I. An irrigation timing warning device. *Bull. Tokai-Kinki Nat. Agr. Exp. Sta.*, 19, 14–23 (1970) [In Japanese, English summary].

3) Naoi, T. & Sekiguchi, J.: Studies on irrigation in mulberry field. I. On water economy of mulberry plants under different soil moisture conditions. *J. Seric. Jap.*, 39, 443–450 (1970) [In Japanese, English Summary].

4) Naoi, T.: Studies on transpiration and evapotranspiration of mulberry field. *Bull. Seric. Exp. Sta.*, 24, 247–285 (1970) [In Japanese, English summary].

5) Naoi, T. & Sekiguchi, J.: Studies on irrigation in mulberry field. II. Instruction apparatus of irrigation. *Sansi-Kenkyu (Acta Sericologica)*, 79, 9–14 (1971) [In Japanese].