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Water losses from an irrigated wheat field at Poona in relation to Pan Evaporation

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ABSTRACT. The loss of water due evapo-transpiration from an irrigated wheat field at Poona, measured directly by the gravimetric method on a daily basis is compared with the loss of water from a standard U.S.A. pan evaporimeter. The comparison has been done by taking cumulative totals. It is seen that the two sets of values lie on a fairly smooth curve but that th ratios between the two vary considerably with the stage of growth of the crop. An attempt has been made to express the relationship between evapotranspiration and pan evaporation in a mathematical form. The study also brings out the large variations in the magnitudes of the water loss due to evapo-transpiration during different growth phases of the wheat crop.

1. Introduction

Among the various climatic factors of hydrological and agricultural significance, the return of moisture to the atmosphere from natural land surfaces occupies an important place. Water losses from a natural surface like a cropped field are made up of evaporation from the bare soil and transpiration from the plants, the combined being known as 'evapo-transpiration'. A number of terms such as 'total evaporation', 'consumptive use', 'irrigation requirement', 'water requirement' etc are used to denote the quantity of water needed for crop production. The term 'water requirement', when used in connection with irrigation, indicates the amount of water required to be applied to the field at adequate intervals to ensure successful crop production. In raising crops with the help of irrigation, the amount of water lost as transpiration constitutes the minimum demand that has to be met. When this is required to be done through surface irrigation the inevitable loss of water as evaporation from the bare patches of soil among the plants has also to be taken into account. The solution of the problem of water requirements of crops lies in the accurate determination of the loss of water by evapo-transpiration from cropped fields.

Numerous attempts have been made to measure evapo-transpiration. Of the many methods that are in use, lysimetrical, soil moisture profile, aerodynamic, eddy correlation and energy balance methods deserve mention. Most of these are, however, laborious require either constant attention by highly skilled staff or elaborate computation. It is well known that evapotranspiration is a function of the prevailing meteorological conditions, the most important of which are vapour pressure, wind and temperature. Similarly, the evaporation from a standard pan evaporimeter is also governed by these factors. An attempt has been made in the present paper to see whether a simple relationship could be obtained between the evaporation from a standard pan, and the actual evapotranspiration from a wheat field during a *rabi* season at Poona.

2. Data used

The actual evapo-transpiration data used in this study have been obtained by the lysimetric method (hereinafter called the gravimetric method). In this method, the plants are grown (right from the germination stage) in containers big enough to allow free growth as in the field. The container is supported on a weighing machine capable of handling large weights. The weighing machine is placed inside another tank of a slightly bigger capacity which is sunk into the middle of a field where a crop of the same variety (in this case wheat) is grown in such a way that the level of the soil in the inner tank (*i.e.*, the tank containing the plants) is the same as that in the field. To simulate field conditions care is taken to see that the soil profile, the date of planting, seed rate, dates of irrigation, dose of manure, other cultural operations etc, with respect to the plants grown in the tanks are kept exactly same as those observed with regard to the plants grown in the field. The soil of the experimental tank is raised to field capacity on days when the crop in the field is irrigated. Proper drainage system is also provided to ensure drainage of excess water when heavy showers occur. Periodical growth observations of the plants in the tanks and of those in field are taken to check whether the plants in the tanks are growing as freely as those in the field.

Evaporation for the same period for which evapo-transpiration was measured by lysimeter, was obtained from a U.S.A. standard pan evaporimeter installed at the Central Agricultural Meteorological Observatory. In order to prevent the loss of water through various extraneous influences like stray animals and birds the pan is covered with a wire mesh.

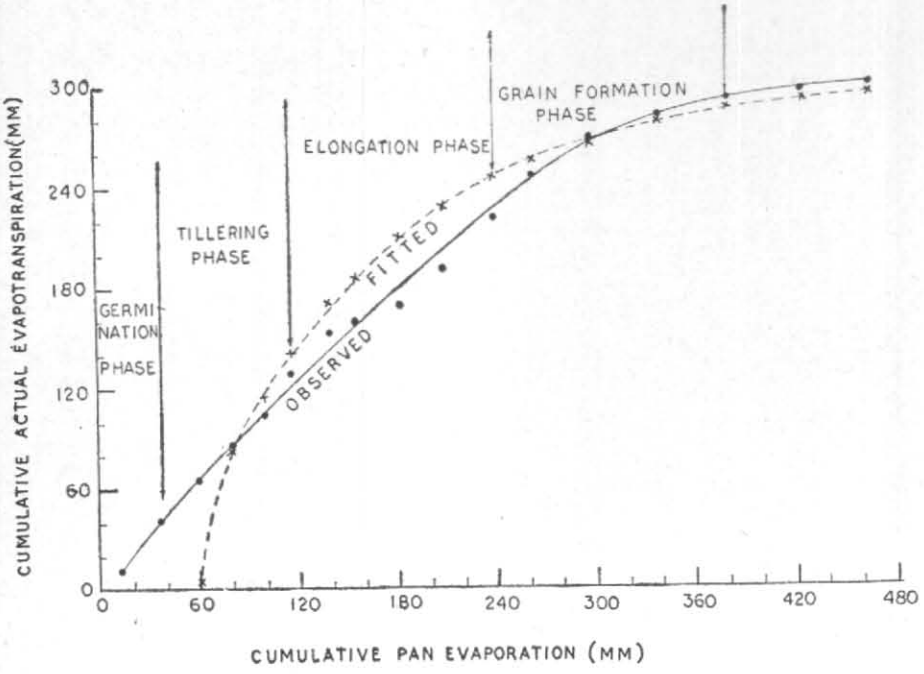

Fig. 1

3. Results

The table given below shows the ratios of the actual evapo-transpiration to pan evaporation during the different stages of growth of the *rabi* (1962-1963) wheat crop at Poona.

Phase of the crop	*Ratio of evapotranspiration to pan evaporation*
Germination	1·14
Tillering	1·17
Elongation (growth)	0·73
Grain formation (maturity)	0·55

It can be seen that the ratio of the actual evapo-transpiration to pan evaporation attains maximum value during tillering phase while the minimum is registered during the maturity phase. From the table it may also be observed that the actual evapo-transpiration increases correspondingly with pan evaporation during the early stages of crop growth (germination and tillering phases) while during the later stages, the ratio drops suggesting that the evapotranspiration decreases considerably in comparison with the pan evaporation.

Scatter diagrams prepared with the help of daily individual values of actual evapotranspiration and pan evaporation separately for different growth periods did not reveal any significant result. Therefore, cumulative values of evapo-transpiration as obtained by lysimeter were plotted (Fig.1) against the cumulative values of pan evaporation starting from the sowing up to the harvest time. It is seen that the two sets of values lie on a smooth curve.

An attempt was made to see wheather a mathematical equation could be fitted to the curve. After several trials an equation of the form—

$$y = 302 \cdot 3 - e^{6 \cdot 06 - 0 \cdot 0083\, x}$$

was derived. In this equation y represents the cumulative actual evapo-transpiration and x the cumulative pan evaporation. The evapotranspiration values worked out from pan evaporation making use of this equation are also plotted in the form of a curve in Fig. 1. Even though this curve does not quite coincide with the lysimetric curve, it may be seen that the total evapotranspiration up to the end of grain formation period can be obtained with this equation to a fairly good degree of accuracy. Even taking into account the individual growth phases the agreement between observed and calculated values is quite close for the tillering and grain formation periods although computed values are somewhat higher for the elongation period.

The study pertains to one kind of soil, crop and a season. In order to extend the results, further experiments are necessary with different soils and crops and in different seasons and climatic zones.

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REFERENCE

Harrold, L. L. and Dreibelbis, F. R. 1951 *Tech. Bull. U.S. Dep. Agric.*, 1050