PHENOLOGICAL OBSERVATIONS ON PEAS

With the best Compliments of The author

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For more than two hundred years, farmers and gardeners in different countries have recorded dates of planting, emergence, leafing, flowering, fruiting etc. of many kinds of plants. At the same time attempts have been made by climatologists to obtain correlations between these various phases of plant development and climatic parameters with special attention to temperature and rainfall. The results of these phenological studies have, however, not been useful as they were invariably handicapped by the fact that the above individual perceptible vegetative phases were separated from each other by very long intervals of time during which the seasonal variations in weather complicated or obscured the true inter-relationships. The problem was therefore to discover a plant whose growth habits were such that the development in a short period (say a day) could be recognized and precisely measured or, in other words, to find a plant that could serve as a climatological instrument.

Recent investigations at the Laboratory of Climatology, Centerton, N. J. (U.S.A.) by Thornthwaite and his co-workers (1954) have shown that the common English garden pea plant possesses all the above desired characteristics; it grows rapidly, has little branching and the growth takes place at a single point. As the stem elongates, successive nodes develop on it within short time intervals. Each node represents a definite stage of development of the plant and the development from one node to the next involves a series of changes in the plant which are readily discernible so that it is quite possible at any time to say what fraction of the development has occurred from the last node to the one that is next to come. The nodes themselves are numbered serially and the stage of development of the plant at any time can be stated precisely by means of a single numerical figure. These detailed observations on garden peas have revealed a great deal about the nature of plant development which can be considered as consisting of what Thornthwaite calls "growth units". The pea plant (or any other plant for that matter) at a given stage of development towards maturity will have passed through a fixed number of these definitely measurable units.

Another important field of study in progress at the Laboratory of Climatology is the determination of water requirements of different crops. From the vast data on evapotranspiration under field conditions, it has become possible to relate the water needs of many cropped plants to temperature and day length. The fact that evapotranspiration and plant growth are related to each other and are both influenced by the atmospheric conditions in almost the same way was used by Thornthwaite to give a new interpretation of the growth-unit. Since close relationships have been established between plant development and climate (through detailed observations on peas in experimental gardens) and at the same time between climate and plants' water needs (through the use of evapotranspirometers planted to different crops) the growth-unit was defined, as the interval between successive nodes on a (pea) plant. Alternatively, using the amount of water needed for evapotranspiration as an index of the amount of development in a plant, the growth-unit can also be defined as the amount of development that will occur while a unit amount of water is used for evapotranspiration. Since it is possible to compute water need from temperature records, the growth-index (total number of growth-units from planting to maturity) can also be determined by computation.

Evaporation and transpiration deplete soil moisture while rainfall restores it. Thus when we know the water needs of a crop and the rainfall, it is possible to compute how the moisture reserves in the soil are depleted or replenished. Such a computation based entirely on a book-keeping procedure evolved by Thronthwaite (1948) can be made from routine weather observations alone and is the basis for irrigation schedules in agricultural and horticultural operations. Table I shows the irrigation requirements of Visakhapatnam obtained as stated above. Figure 1 is the graphical representation of the average water need and rainfall (on a monthly basis) at Visakhapatnam ; it can be observed that although water deficiency is

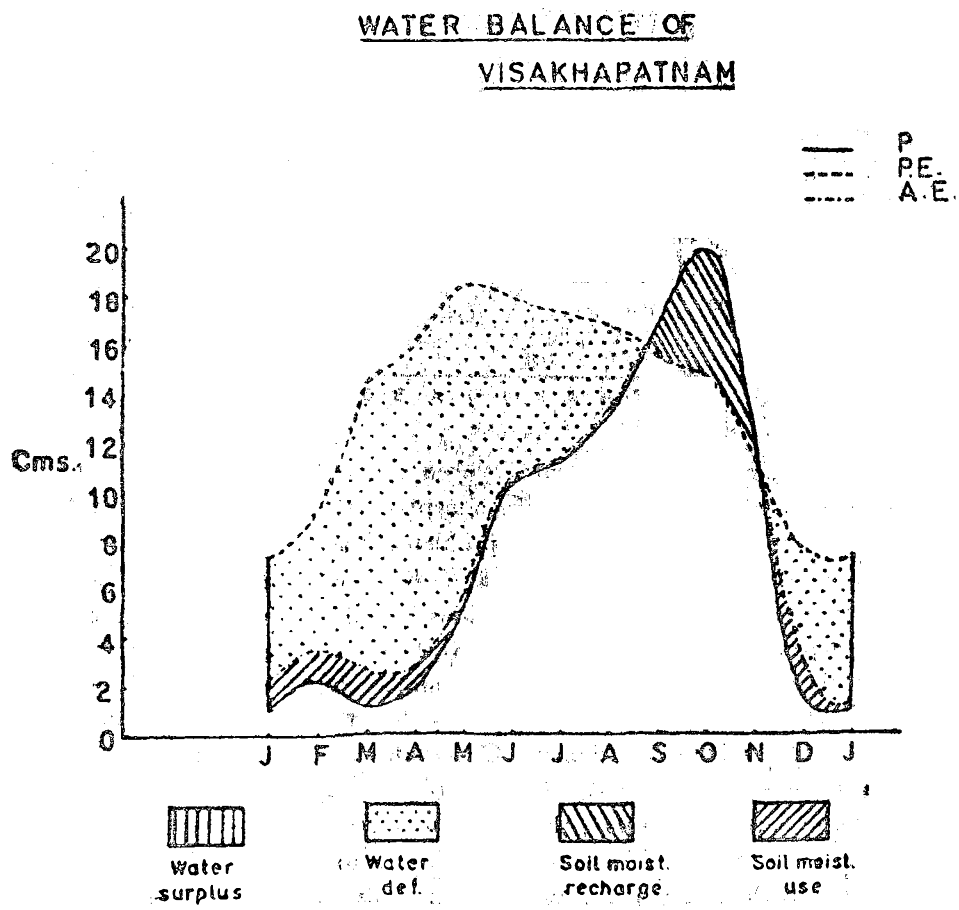
TABLE I.

Growth Units at Visakhapatnam through the Year

Months	P.E. (cm)	Cumulative growth-units (1 cm = 100 g.u.)
January	7.4	740
February	9.4	1680
March	14.4	3120
April	16.1	4730
May	18.4	6570
June	17.9	8360
July	17.4	10100
August	16.9	11790
September	15.5	13340
October	14.7	14810
November	10.9	15900
December	7.6	16660
Year	166.6 cm.	16660 growth units.

present most of the time during the year, a part of winter and early summer are times of severe water deficit and only at the peak of the south-west monsoon is the water supply from procipitation is just enough to meet the demands of water need. Although in the monsoon season rainfall is higher than the water need, this excess goes only to re-charge the soil reservoir, which has been very much depleted in the preceding dry season. From early November to the middle of September water need is higher than precipitation and this deficiency represents the amount of water that should be supplied by sources other than precipitation, as supplemental irrigation.

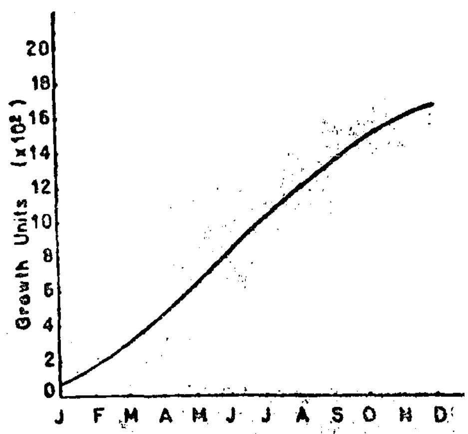
Fig. 1.



Climatic data: ANNUAL PRECIP. 96.2 Cm.
„ „ POT. EV. 166.6
„ „ ACT. EV. 96.2
„ „ WAT. SUR. 0.0
„ „ WAT. DEF. 70.4

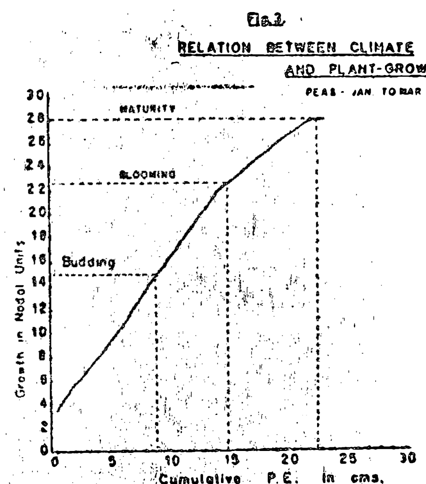
Since as has been mentioned earlier, the water need and the growth units are the same, the curve of mean daily water need also represents the daily growth potential and is shown in Fig. 2. Growth units at Visakhapatnam accumulate at the rate of 2.4 a day in January and rise to a maximum of about 6 a day in May and then the rate declines. Expressed graphically, this takes the form of a stretched S-curve which relates the growth of the plant to march of time from the date of planting.

Fig. 2
GROWTH CURVE AT VISAKHAPATNAM



Studies of this nature have not so far been made in our country but these new approaches are based on rational concepts and are therefore expected to yields practical solutions to the moisture problems in agriculture. As a preliminary step towards such an objective, Thornthwaite's work on garden peas was undertaken at Waltair with all the field precautions strictly observed. In a carefully prepared plot peas were planted in six rows with six saedlings in each row and the central four plants were used for the experimental study. The plot and the surroundings were kept thoroughly watered every day to ensure that the plants never sufferred from any moisture deficiency. Observations of maximum and minimum temperatures were obtained from the nearby screen. The mean temperature of the day was used for computing the water need (potential evapotranspiration) according to Thornthwaite's formula (1948) taking into consideration the daylength factor. The growth of the plant was measured as per the growth-unit system and the mean development of the four plants was used in the analytical study.

The mean growth of the plants was plotted against the cumulative growth-units and the curve so obtained is shown in Figure 3. Certain very interesting features of climatic relations to plant growth become evident from the diagram. The rate of growth during the vegetative sub-periods remains essentially constant but shows a marked change (as seen from the change in slope of the curve) at and after the onset of the next phase. In the present experiment the rate was 68.5 growth-units (g. u.) per node from germination to blooming and 132.2 g.u. from blooming to maturity ; it is also interesting to note that the slope is halved with the blooming and remained so, until seed-setting after which there was no further growth. Budding, although considered to be a phase of plant life has not shown any significant change in water requirements ; it is possible that the appearance of buds is not of much morphological significance and it is only after blooming that a considerable part of the plants' energy is directed to the seed that is in formation.



A repetition of the same experiment during the pre-monsoon period when the sunshine was not much interrupted gave almost the same relationships ; it was not proposed to conduct the work during the monsoon season due to the uncertainty of the sunshine duration as well as possible damage to plants by frequent and heavy showers.

Girolamo Azzi (1956) states that the dates of appearance and rhythm of succession of the phases of development are strictly correlated to temperature, humidity and also to the lengths of day and night. He also points out, however, that it is only the three phases, sprouting, earing and maturity, which are of great importance and interest in relation to plants' adaptation to climatic conditions. Many plant scientists believe that in the tropics, any part of the year is a good enough growing period provided the moisture conditions are adequately taken care of. The present work can therefore be conducted in seasons other than those mentioned above. It would also be of immense usefulness to extend these studies to other kinds of plants particularly the food-crops ; this would probably call for a proper system of growth-measurement for indigenous plants.

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