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PECULIARITY OF DETERMINATION OF VINE'S WATER REQUIREMENT

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Abstract: *Among the many natural and climatic factors affecting the dynamic processes of agricultural crop development a special significance acquires such climate index, as evapotranspiration (ET). Determining factors of evapotranspiration for the different climatic conditions are key indicators of water requirement and its optimal productivity for agricultural crops.*

For determination of the vine evapotranspiration was used Blaney-Criddle method according to which with high accuracy were determined Regulated Deficient Irrigation (RDI) of vine's crop.

On the basis of the 2013 experiment using the method of L. Williams at the experimental plot of the Georgian Agrarian University for the vine breed "Rkatziteli" we identified the crop coefficient (K_c) and respectively its water requirement during the crop growing season.

Key words: *evapotranspiration; coefficient of biological water demand; regulated deficient irrigation.*

1. INTRODUCTION

The influence of agrometeorological factors and modern irrigation technologies on the vine's water requirement and respectively on grape yield and its qualitative indices has hardly been studied. These issues require special attention gaining global climate change.

Georgia became involved in global warming and the some negative impact of the country's agriculture has been made. As a result, significant alternation of air temperature, precipitation, solar radiation and other climate indicators, caused serious harm of agricultural crops, especially - the vine. Considering that viticulture is the profiling sector of country's agriculture and its share in total agriculture production 20-25 years ago was of 18-20 per cent it's easy to imagine what a great loss is expected. Water shortage and, therefore, lack of moisture due to the vine cannot develop normally and received product has a low quality. This often caused crop losses of over 30-40 per cent. Increase in temperature and decrease in precipitation observed in the viticulture regions of eastern Georgia. During such global climate change observed trend of deterioration of product's quality.

In this regard, introduction of drip irrigation, as the modern irrigation technology in irrigation farming viticultural regions can be considered as the most efficient for productive usage and management of water resources. Drip irrigation technology provides maximum, sustainable and ecologically pure crop adoption of minimum labor, material and technical resources charges on final emblements per unit volume. It is necessary to note, that drip irrigation technology actually eliminates the risk factor for providing of vine's water _ supply of the entire crop growing period. This is argue with the results of large-scale usage of drip irrigation in the United States, where this technology is used at 2 000 000 hectares in viticulture regions, such as California and Washington.

Models for agricultural productive process mainly developed for annual crops. This, primarily, can be explained by the fact, that in perennial crop formation more complex and numerous factors are involved and architectonic and geometric structure of perennial plants (vines) is complicated. Therefore, the quantitative description of radiation, heat transfer and water regimes of vines canopy involves great difficulties.

2. THE BODY OF THE ARTICLE

Increasing of vine productivity (yield and quality) requires quantitative assessment of agrometeorological, agricultural and technological processes. These issues are actual and their study and practical application of obtained results will significantly improve irrigated viticulture regions, the socio-economic situation by the intensification of agricultural production, which includes modern irrigation technology – usage of drip irrigation technology, based on the analysis of local natural and climatic characteristics database, that provides regulation of vine productivity and grape quality characteristics.

From such dynamic process, as air temperature, atmospheric precipitation, relative humidity, wind speed and direction, solar radiation, soil temperature and humidity that affects to growth and development of agricultural crops, it assumes special importance such comprehensive indicator, as evapotranspiration, as it is the major expenditure component of the water balance.

The study of evapotranspiration and its determining factors in the different climatic conditions is the basic indicator for determination of crop water requirement and optimal productivity of water resources.

In order to determine vine's water requirement in condition of limited climatic indicators it can be used Blaney-Criddle [1] evapotranspiration determining method, that is recommended by the UN Food and Agriculture Organization (FAO), which makes it possible to determine the crop water requirement.

Evapotranspiration of crops is generally determined by the formula [1]:

$$ET_c = K_c \times ET_0, \text{ (mm)}$$

where:

ET_c is the actual evapotranspiration, mm;

ET_0 – reference evapotranspiration, mm;

K_c – crop coefficient, which depends on the biological characteristics of the crop and climatic conditions.

In order to determine agricultural crop's reference evapotranspiration (ET_0), we use FAO-recommended Blaney-Criddle empirical formula [1]:

$$ET_0 = C\left[P\left(0.46T + 8\right)\right], \text{ mm/per day,}$$

where:

T is the average daily temperature, °C;

P – daily percentage of annual daytime hours %;

C - correction coefficient.

For example, in 2013, during the experiment provided at the experimental plot of Georgian Agricultural University, value of evapotranspiration was highest in July:

$ET_0 = 6{,}0$ mm/per day.

Given that K_c=0,65, the vine's evapotranspiration will be:

$ET_c = 3{,}9$ mm.

Considering the vine Regulated Deficient Irrigation (RDI) – 75%, then:

$ET_c \approx 3{,}0$, mm/per day

The dropper consumption of each vine take up to 3 l/h, while the location scheme of vines on total area - 2m x 2,5m. Under this scheme on 1 ha area the number of vines will be 2000. Amount of water to be supplied in 1 hour will be equal to: $W = 6$ m^3.

Irrigation rate of a single vine takes up to 6 l/hr. Then for irrigation of 1 ha it will be necessary $12m^3$ of water amount. For ten time irrigation it will be necessary of 120 m^3 of water amount, for twenty time - 2400 m^3, etc.

The amount of water, which loses, as a result of the vine transpiration in a certain period of time, may vary according to the development of the vine's canopy. Accordingly, for the vine crop coefficient K_c, with respect to the reference evapotranspiration, we can determine only that amount of water, which was used by the vine. It is known, that vine crop is highly adapted to drought and accordingly the value of its crop coefficient is much less than indicators of such reference crops as alfalfa or grass. Vine crop coefficient varies during the crop growing period and is directly linked to the growth and development of vine's canopy.

In general, in the conditions of full development of vine's canopy $K_c = 0{,}65$ for wine varieties and $K_c = 0{,}85$ – for table grapes varieties.

According to the L. Williams method, vine water requirement can be determined [2]:

$$ET_c = \frac{ET_0 \times K_c}{E_{ff}},$$

where,

ET_0 is a reference evapotranspiration per day, week, etc., mm;

K_c – crop coefficient;

E_{ff} - irrigation efficiency, which during usage of driping irrigation technology varies within 0,85-0,95.

For determination of K_c for red wine varieties of vines, that was found by L.Williams, vine canopy's shaded area is in linear correlation with as vine water requirement (ET_c), as with (K_c) when the sun at noon (12^{30}-13^{30} hr) is in the zenith.

L. Williams was found relationship between K_c and the percentage value of shaded area at the bottom of the vine plant [2]

$$K_c = 0{,}002 + 0{,}017x$$

Where x is the ratio of vine shaded area in the bottom of plant with the area occupied by the single vine, expressed as a percentage and the numeric indicator 0.017 is the value of slope of equation of linear correlation between shaded canopy's area percentage and crop coefficient.

There are several reasons why the vine's water requirement and crop coefficient is related to percentage of shaded area in the bottom of plant in a case, that sun is located in the zenith.

- The highest rate of solar radiation is observed from 11am to 14pm hours of the day;

- Approximately 75% of daily usage of water is from 10am to 14pm;
- The vine shaded area in the bottom of plant is indirect indicator of solar radiation absorbed by canopy;
- The vine shaded area in the bottom of plant is changing from 9am at 3pm;
- During vine growth and development stage, absorbed solar radiation gradually increasing (rising shadow area) and accordingly increasing water requirement until they established a stable canopy development conditions (in accordance with the shaded area)

The L. Williams method was adapted at the Tbilisi's Digomi experimental plot for vine breed "Rkatsiteli" foresight the full range of the local weather conditions.

There were determined crop coefficient and accordingly actual evotranspiration with considering of regulated deficient irrigation in the following order:

- Area occupied by single vine in our case was:

$$\omega = \ell \times b = 2.0\text{m} \times 2.5\text{m} = 5.0\text{m}^2,$$

where

ℓ is the distance between the vines, m;

b - the distance between the vine rows, m.

- The vine canopy shaded area in the bottom of plants was average of 0.5 m (taken from 12^{30} hr to 13^{30} hr period, where the sun is in the zenith);
- Canopy grape vines at the foot of the canopy of the shadow width where the sun is in the zenith);
- Vine's single shadow area (SSV) is determined by:

$$SSV = 2.0\text{m} \times 0.5\text{m} = 1.0\text{m}^2.$$

- The percentage of shaded area in relation to area occupied by single vine will be:

$$PSA = \frac{SSV}{\omega} \times 100\% = \frac{1.0\text{m}^2}{5\text{m}^2} \times 100\% = 20\%.$$

During the given stage of vine growth and development the crop coefficient in our case will be:

$$K_c = PSA \times 0.017 = 20 \times 0.017 = 0.34.$$

Vine crop coefficient for III and IV stages of development is K_c=0.34.

It should also be noted, that on the basis of specific nature of local agro-technical events, vine crop coefficient, that was obtained and calculated during the experiment, is 1,5 times less than values found by L.Williams in the same stages of development and growth.

This is primarily due to the fact, that in Georgia it is decided to spend so called vine's "Green operations", which is almost impossible in the US, because vine-occupied areas are very large.

3. CONCLUSION

Conducted experiments and computations show, that taking into consideration the particularity of natural and climatic conditions and the characteristics of the vine cultivation in Georgia it is possible to determine crop coefficients for all stages of growth and development of wine or table vines and accordingly determine water requirement for the whole crop growing period with considering regulated deficient irrigation, that can be provided by usage of drip irrigation technology.

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