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DETERMINING THE NEED OF ALFALFA FOR WATER IN THE CONDITIONS OF SARAJEVO AREA (BOSNIA AND HERZEGOVINA)

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ABSTRACT

Alfalfa has a great need for water, because it creates a huge plant mass. For this reason, yield level, similar to the other species with large green mass, primarily depends on provided water during the growing season. Alfalfa uses water well from the pre-vegetation reserve in land, especially of rainfall during the growing season. In this paper, the need for water in alfalfa for average, the most rainy and dry hydrological year in the conditions of Sarajevo area was established. Evapotranspiration of alfalfa is 567 mm for the most dry, 569 mm for the most rainy and 540 mm for average hydrological year. Water deficit occurs in May, June, July and August in the amount of 323.9 mm for the most dry, 178.4 mm for the most rainy and 222.1 mm for average hydrological year. In the study area, alluvial soil is predominant (fluvisol), which is of a light mechanical composition (sandy loam) and favorable chemical characteristics for alfalfa growing.

Keywords: *alfalfa, evapotranspiration, water deficit, land.*

INTRODUCTION

Crop water demand can be defined as the amount of water required to compensate for water losses in crop occurring in evapotranspiration of crop which grows in terms of the lack of readily available water and nutrients and achieves the maximum development of green matter. Water needs of crops are expressed through evapotranspiration (Doorenbos and Pruitt, 1977) which includes plants transpiration and evaporation from land covered with vegetation cover.

Alfalfa requires and consumes large amounts of water; it has a very high transpiration coefficient and high production of green matter per hectare (Lukic and Katic, 1994). Alfalfa uses water well from the pre-vegetation reserve in land, especially of rainfall during the growing season (Balaceanu and Balaceanu, 1994). In the case of drought alfalfa vegetates thanks to its powerful roots. The depth of the roots of 5-6 or more meters (Miskovic, 1986), or 7-8 or even up to 10 m (Fazakas et al., 2006), allows alfalfa to use water from deeper layers. Alfalfa in favourable years, with favorable moisture, achieves high yields (Bosnjak et al., 1988). Although alfalfa is drought tolerant, it responds well to irrigation (Dragovic et al., 2000).

The needs of plants for water depend on several factors, primarily from the area, weather and soil conditions, the level of nutrition, applied agricultural technology, features genotype and so on. Knowing the need for water provides a rational watering, saving water (Neufeld and Davison, 1998). In addition to familiarity with the type of climate and water balance of a given area it is necessary to know some basic characteristics of soil types, because it is very important to know how much water sediment of rainfall reaches the land, and how much is retained in the soil, which primarily depends on the type of soil and its mechanical composition.
Taking into account Sarajevo area, the aim is to determine the real needs of alfalfa for water, and to determine the characteristics of one of the dominant soil types.

MATERIALS AND METHODS

The calculation of reference evapotranspiration (ET_0) was made by the FAO-56 Penman-Monteith method, which was proposed by FAO as a standard applicable in all weather conditions and in all time periods (Allen et al., 1998). Climate data for part of the Sarajevo area has been set for a twenty-year period (1995-2015), and potential evapotranspiration, effective precipitation, and water deficit have been determined for the most dry, the most rainy and average hydrological year.
Evapotranspiration of alfalfa has been calculated using the following formula:

$ET_k = ET_0 * k_c$
ET_k- crop evapotranspiration,
ET_0- potential evapotranspiration,
k_c- crop coefficient,

USDA Soil Conservation Service method has been used for calculation of the effective rainfall:

Water deficit has been calculated using the following relationship:
$D_V = ET_0 - Pef$
D_V – water deficit,
ET_0 – potential evapotranspiration,
Pef – effective rainfall,

Mechanical composition of the soil has been determined by international B method, and textural classes of land have been determined by Fere triangle (Soil Survey Manual,1955).
Basic chemical properties have been determined by the following methods:

- pH value – by means of pHmeter in suspension with water and 1M KCl ;
- content of $CaCO_3$ volumetric;
- humus content by Kotzman;
- N content by Kjeldahl method;
- P content by Al method;
- K content by Al method.

RESULTS AND DISCUSSION

The most necessary amount of water for crop cultivation in the open field, in our climatic conditions during the growing season comes from precipitation. The difference between the total water needs of crops and the inflow of water precipitation (effective or useful for the plant) makes water deficit that must be compensated by irrigation.

Tables 1, 2 and 3 show the total rainfall, effective precipitation (precipitation beneficial for the plant), potential evapotranspiration, alfalfa evapotranspiration and water deficit at different stages of the alfalfa vegetation period of average hydrological year. Effective rainfall for average hydrological year amounted to 773.5 mm (Table 1), 927.6 mm for the most rainy hydrological year (Tab.2), and 588 mm for the most dry hydrological year (table 3). Evapotranspiration of alfalfa is 540 mm (average), 569 mm (wettest), 567 mm (driest) hydrological year (Tab.1, 2, 3). Water deficit for alfalfa occurs in May, June, July and August in a total amount of 222.1 mm, and the largest water deficit was recorded in July in an amount of 111.1 mm.

In the most rainy hydrological year (Table 2), deficit of water for alfalfa was lower and amounted to 178.4 mm, expressed also in May, June, July and August, with the largest deficit in June, in the amount of 56.8 mm.

In the rainiest hydrological year (Tab.3), deficit of water for alfalfa was amounted to 323.9 mm, expressed also in May, June, July and August, with the largest deficit in August in the amount of 104.5 mm.

Water requirements determine amount of irrigation (Schwankl and Prichard, 2003). Schewmakera et al. (2001) found that water surplus does not contribute to increase in yield. Therefore, rational irrigation is necessary by applying climate formulas (Zypries and Yevtushenko, 1980), where the coefficients should be adapted to stages of growth and development.

Table 1. Alfalfa needs for water (average hydrological year -2012)

Months	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**I**	**II**	**III**	**year**
P (mm)	45	63	148	26	32	95	48	113	100	105	70	62	1.144
P_{ef} (mm)	41.8	56.6	113	24.9	30.4	80.6	44.3	92.6	84	87.4	62.2	55.8	773.5
ET_0	45	78	117	124	116	70	30	26	0	0	0	20	626
ET_l	30	78	123	136	110	63	0	0	0	0	0	0	540
D_V	0	21.4	10	111.1	79.6	0	0	0	0	0	0	0	222.1

P- precipitation; P_{ef} – effective rainfall, ET_0 – potential evapotranspiration; ET_l- alfalfa evapotranspiration;
D_V-water deficit;

Table 2. Alfalfa needs for water (the most rainy hydrological year -1999)

Months	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	year
P (mm)	106	72	74	100	84	106	56	142	298	49	59	57	1203
P_{ef} (mm)	88.0	63.7	65.2	84.0	72.7	88.0	51.0	109.7	154.8	45.2	53.4	51.8	927.6
ET_0	52	95	116	119	122	79	48	12	0	0	0	18	661
ET_l	34	95	122	131	116	71	0	0	0	0	0	0	569
D_V	0	31.3	56.8	47	43.3	0	0	0	0	0	0	0	178.4

P- precipitation; P_{ef} – effective rainfall, ET_0 – potential evapotranspiration; ET_l -alfaalfa evapotranspiration;
D_V -water deficit;

Table 3. Alfalfa needs for water (the most dry hydrological year -2000)

Month	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	year
P (mm)	52	69	23	50	17	73	84	76	98	34	48	33	657
P_{ef} (mm)	47.7	61.4	22.2	46.0	16.5	64.5	72.7	66.8	82.6	32.2	44.3	31.3	588
ET_0	55	91	112	127	127	68	68	51	33	2	0	0	734
ET_l	36	91	118	140	121	61	0	0	0	0	0	0	567
D_V	0	29.6	95.8	94	104.5	0	0	0	0	0	0	0	323.9

P- precipitation; P_{ef} – effective rainfall, ET_0 – potential evapotranspiration; ET_l -alfaalfa evapotranspiration;
D_V -water deficit; S_V-water surplus;

According to the soil map of Bosnia and Herzegovina (Resulović et al., 2008) in the area of Sarajevo, one of the most common types of soil is alluvial soil (fluvisol).

Table 4. Mechanical composition of soil type alluvium (fluvisol)

Sampling depth (cm)	**Large sand 2-0,2 mm (%)**	**Small sand 0,2-0,02 mm (%)**	**Powder 0,02-0,002 mm (%)**	**Clay <0,002 mm (%)**
0-30	10.99	46.85	23.00	19.16
30-60	10.5	44.65	25.90	18.70

According to texture, soil type fluvisol belongs to a class of sandy loam (Table 4), which means that this soil has favorable physical properties due to the appropriate ratio of water and air in its micro and macro pores.

Table 5. The chemical composition of soil type alluvium (fluvisol)

Sampling depth (cm)	**pH/H_2O**	**pH/KCl**	**$CaCO_3$ (%)**	**Humus (%)**	**Total N**	**P_2O_5 (mg/100 g)**	**K_2O (mg/100 g)**
0-30	7.28	6.18	1.2	2.4	0.151	36.8	35.6
30-60	7.51	6.80	1.4	2.5	0.158	37.9	36.6

Chemical analysis of samples taken from soil type fluvisol shows that the land is slightly acidic to neutral, and from that standpoint, it is favorable for the cultivation of alfalfa. This soil is with lower carbonate content, medium secured humus, well secured accessible phosphorus and potassium (Tab.5).
According to Resulović et al., (2008) in soil type fluvisol, humus content is not evenly distributed regarding depth profile, which means that deeper layers of the profile can be more humous, which is proved by these soil samples.

CONCLUSION

Investigated area is perfect for growing alfalfa, due to favorable climatic and soil conditions. The deficit of water for alfalfa occurs mainly in the summer months, when there is not enough effective rainfall (rainfall useful for the plant) and then irrigation should be applied. The dominant soil type on the part of Sarajevo area is alluvial soil (fluvisol), which is suitable for growing alfalfa due to its physical and chemical properties.

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