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YIELD FORECASTING FOR OLIVE TREE BY METEOROLOGICAL FACTORS AND POLLEN EMISSION

Aferdita LASKA MERKOCI[1], Albana HASIMI[2], and **Mirela DVORANI[3]**

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ABSTRACT

The paper aims to forecast the olive product based on the application of a statistical model by use of meteorological factors and pollen emission. Nowadays there are a number of models and approaches related to the yield forecasting. All of them have their advantages and disadvantages and moreover different behaviours for climate conditions of Albania. Thus, after a preliminary evaluation the best fitted model was chosen and its result were analysed. The model was based on the multiple equations of regression, which took into consideration some climate factors. These factors are rainfall in May followed by rainfall in June. Minimum temperatures during spring and summer were also an important consideration due to the influence of night temperature on energy collected for fruit development.

The use of pollen emission and monthly meteorological data from 1985-2004 as predictive variables has enabled the production of a forecast up to 8 month prior to the end of harvesting.

The forecasting of yield production in this study has been made in November, which reflects the EPP and the meteorological factors like minimum temperature, maximum temperature, rainfall from May to October etc.

In addition, as the model requires, the most significant periods for this plant were chosen and evaluated for the Vlora region of Albania with the highest productivity in the country.

Results were compared with real olive crop data and estimates from the equation resulted to have a correlation coefficient about 0.77 and SE=3.0.

[1] **PhD. Aferdita LASKA MERKOCI,** aferditamerkoci@yahoo.it, Polytechnic University of Tirana, Albania, Institute of Geosciences, Energy, Water and Environment, Department of Climate and Environment

[2] **PhD. Albana HASIMI,** alhasimi2000@yahoo.gr, Polytechnic University of Tirana, Albania, Institute of Geosciences, Energy, Water and Environment, Department of Climate and Environment

[3] **Msc. Mirela DVORANI**, mndrit@yahoo.com, Polytechnic University of Tirana, Albania, Institute of Geosciences, Energy, Water and Environment, Department of Water Economy

Key words: equations of regression, forecasting, meteorological factor, olive, yield product.

INTRODUCTION

The study of the effects of meteorological factors on crop production and the development of models for forecasting the yield has been the concerns of agro meteorologists worldwide. Crop yield forecasting is important for national food security including early determination of the import/export plan and price. It is also important in providing timely information for optimum management of growing crops (Varga-Haszonits,1983). Therefore, the initiative to study, evaluate and estimate olive production based on the most favorable model for the conditions of Albania was undertaken.

In agro meteorological studies different models are used to evaluate expectancy yield. All of them have their advantages and disadvantages. Hence, after a thorough evaluation, the most appropriate model was chosen and its results were analyzed (WMO, 2004).

The model of multiple regression equation that takes into account all climate elements is used for conditions of Albania.

MATERIAL AND METHODOLOGY

Study Area. Overview of Albania's olive culture

Albania is a Mediterranean country where the olive tree is thought to have originated from. For more than 3,000 years olives and olive oil have been one of the most celebrated food products; they represent a traditionally valued source of healthy nourishment.

Different parts of Albania have a great potential for olive cultivation and it can raise employment opportunities in rural areas. Thus, a new program on sustainable development of this sector aims at approaching the Albanian legislation with the European Union (EU) framework.

During 2015, farmers all over Albania increased investments on olive plants and their sub-products. A total of 12,000 tons of olive fruit was produced and half of it was exported.

Experts from the agricultural sector say that Vlora region ranks first in the country for olive oil production and export. The same specialists say that if farmers would invest more in this sector, the Region would have more incomes from agriculture (Dodona *et al*.2004)

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Not only Vlora but also the Riviera and the entire southern region had a plenteous harvest during the last year. The olive oil produced in the region is recognized as a high-quality product.

Since 2010, over 450 farmers received financial support for olive oil cultivation, while production in 2015 was twofold compared to the previous year. According to USAID Albania there are about ten million olive trees in the country.

For more than 3,000 years olives and olive oil have been one of the most celebrated food products; they represent a traditionally valued source of healthy nourishment.

Figure 1: Geographic distribution of olive trees by districts.

Olives are among the most important fruit tree crops grown in Albania, covering an estimated 8% of the arable land. As shown in Figure 1, the Albanian olive production zone covers the entire coast from Saranda (South) to Shkodra (North) and inland river valleys in the districts of Peqin/Elbasan, Berat/Skrapar, and Tepelene/Permet.

At the end of the Second World War, Albania had about 1.5 million olive trees. By 1990, the number of olive trees increased to 5.9 million covering 45,000 hectares (Saranda, Vlora, Berati, districts etc. During the privatization of farm land in 1991 and 1992, 45,000 hectares of olive groves were distributed to 110,000 households, resulting in highly fragmented olive production. In this paper is taken in study of Vlora Region. This town is surrounded by gardens and olive groves. Vlora has a Mediterranean climate with cool wet winters and hot, (Grup autorësh, 1978), dry summers with temperatures exceeding 30°C (86 °F) in July and August. Table 1

Table 1: Climate conditions of Vlora region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average High ^{0}C	13	14	16	19	23	27	30	30	27	23	19	15	21.3
Average Low ^{0}C	6	6	8	10	14	17	19	19	16	14	11	8	12.3
Daily Mean ^{0}C	9.5	10.0	12.0	15.0	19.0	22.0	25.0	24.5	22.0	19.0	15.0	11.5	17.0
Average Precipit mm	120	106	92	79	54	28	9	26	32	116	192	142	995
Mean Month. Sunsh. hours	133	147.9	173.6	225.0	272.8	318	368.9	344.1	279	210.8	117	99.2	2689.6

STATISTICAL AND MODELING ANALYSES

The study was performed in the Vlora area (South West) in a territory characterized by olive groves. The early olive yield, considered as a dependent variable in the study, expresses the total olive production for these regions (Clementi et al., 2001). The data used for the regression analysis were obtained from the data bank of the Institute of Geosciences, Energy, Water and Environment.

The pollen was monitored using volumetric pollen trap, located at the Agricultural University of Vlora about 530m above sea level. Phenological observations in the field were made at the same time as the pollen monitoring to test the significance of the monitoring itself (Edmonds, 1979).

The pollen monitored in the atmosphere has been captured continuously since 1985 and is reported as the number of daily pollen grains/m^3 (Galan *et al*. 2008) , during the entire flowering period. Starting with daily data, annual EPPs where constructed (1985-2010) by ending pollen concentration peak in the atmosphere. This period corresponds to maximum flowering. The EPPe was derived from the interaction between the EPP values and the mean values of precipitation, maximum and minimum average temperatures during the EPP. The EPPe value was derived from the direct proportional ratio [EPPe=(EPPxT)/1000, where T – Temperature in ^{0}C] and the inverse [-EPPe = (EPPxT/100] between the EPP values and the mean values of the meteorological variables indicated (Galan *et al*, 2004)
Meteorological data were obtained by, IGEWE (ex Hydrometeorological Institute), which registers a series of meteorological parameters (e.g. precipitation, temperature, solar radiation, atmospheric pressure, wind, etc. (Laska *et al*. 2014). The meteorological station has been located in the regions under study and collects this data. Daily values were elaborated to obtain chilling units (CU), growing degree hours (GDH) and GDD for the year being studied, t, and the preceding year, t-1, for all years considered.
Chilling units were calculated using the Utah method (Anderson *et al.*, 1986). A thermal range of 3^{0}C to 9^{0}C was considered optimal, and the maximum chilling value was assigned. Above and below these temperatures, the chilling effects were reduced. The chilling amounts were calculated starting from two different dates (1 December and 1 January) until six final dates (15 January, 1 February, 15 February, 1 March, 15 March and
1 April), giving 12 different values (Laska, 2008). The onset was determined in other studies taking into account the biological cycle of olive in the investigation area (Candau *et al*., 1998).
The GDH were calculated by using the method of Anderson (Anderson *et al.*, 1986) while the GDD were calculated using the method proposed by Baskerville and Emin (1969), which uses 12 threshold temperatures from 4^{0}C to 15^{0}C.
The GDH and GDD amounts were calculated from daily values starting from two onset dates (1 January and 1 February) until the dates of maximum pollen concentrations in the atmosphere (peak of pollination).
Regarding the meteorological variables, the sums of the monthly and total cumulative values were calculated for the maximum, minimum and average temperatures in the summer (June-September) to obtain a summer thermal stress indicator and indirectly, a water stress indicator. A linear regression model was constructed using the S-Plus statistical software to apply the normal test for verifying the robustness of the model (Cammen *et al*.2008).

RESULTS AND DISCUSION

In Table 1 are presented the annual values of EPPe used in the forecasting model. For the periods under study (1985-2004), better results were obtained using the average temperature in the direct proportion ratio with the annual EPP values compared with the values obtained using the precipitation and the minimum and maximum temperatures values. This is probably due to the fact that the average of temperature expresses the thermal trend better for a given period by mediating the extreme values that can be recorded with the other temperature variables. In addition, in a summer-flowering, the precipitation is not correlated with the event while it plays a determining role in the phases immediately proceeding the phenomenon (Fornaciari *et al.*, 2005). At the Table 2, certain annual variability can be observed that are closely linked to the production variability.

Table 2: EPPe Effective pollination period elaborated values realized calculating the direct proportionality ratio between EPP- effective pollination period and meteorological data (average variable in the same periods)

Year	EPPe			
	T_{min}	T_{max}	T_{mean}	Precipitation
1985	213	460	336	16
1986	120	180	150	92
1987	305	820	562	8
1988	120	215	167	0
1989	110	225	167	0
1990	150	310	230	0
1991	80	145	112	0
1992	125	192	158	160
1993	260	430	345	0
1994	305	480	392	0
1995	240	465	351	0
1996	715	1210	962	24
1997	350	632	491	0
1998	108	172	140	0
1999	854	1387	1120	0
2000	187	198	192	8
2001	120	215	167	0
2002	165	278	221	0
2003	172	280	226	0
2004	270	468	369	20

The high performance values of the pollen parameter confirm the relationship between the flowering event and the phases of fruit formation. It also explains the particular collaboration used in this study. It can also be said that with higher average temperature, the pollen transport capacity increases.

The analyses of correlation between production and meteorological variables (CU, GDD, GHD) in the years t and t-1 showed the best result with the cold accumulation December-February t-1 period while scarcely relevant results were obtained with the two parameters related to heat accumulation in both years. Therefore, it can be deduced that there exists a strong relationship between cold and olive production in the region of Vlora on the Albanian territory. This relationship could also be determined by the regime of the climate (Laska, 2008).

The use of pollen emission Figure 2 and monthly meteorological data from 1985-2004 as predictive variables has enabled the production of a forecast up to 8 months prior to the end of harvesting.

The forecasting of yield production can be made in different phenological periods. But in this study the forecast has been made in November, which reflects the EPP and the meteorological factors like minimum temperature, maximum temperature and rainfall from May to October.

According to the results of table 2, the independent variables of multiple regressions were chosen. The regression coefficients were calculated using the meteorological data of the period 1985-2004.The equation for the region under study is presented as follows:

$$Y = -129234 + 6592x_1 + 51x_2 - 7198x_3 + 1498x_4 + 7698x_5 - 7192_6 - 85213x_7$$

R=0.77 SE=3.0 F=2.6

Where:

Y – product;

X_1- rainfall in May (RfMy);,

X_2-pollen (EPP);

X_3- maximum temperature in October (MxTO);

X_4-rainfall in October (RfO);

X_5-rainfall in July (RfJl);

X_6-maximal temperature in October;

X_7-minimum temperature in July (MnTJl)

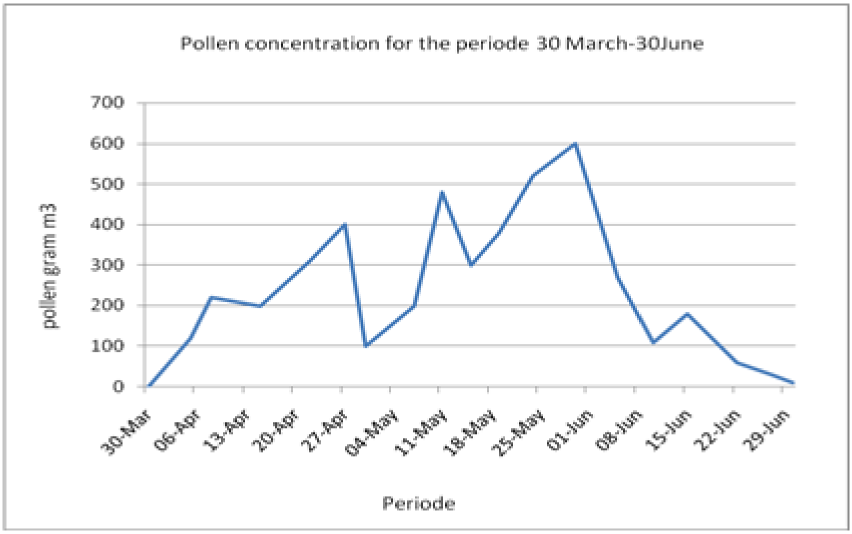

Figure 2: The daily pollen emission 30 March-30 June

It can be observed that the EPP and precipitation values that have been entered in the equation are positive. Other parameters that were taken into account were the air maximum and minimum temperatures, with minimum temperature affecting crop development negatively and maximum temperature favoring fruit production Figure 3. During October, the temperature exerted an opposite effect with maximum temperature negatively influencing crop development and minimum temperature being positive for crop production.

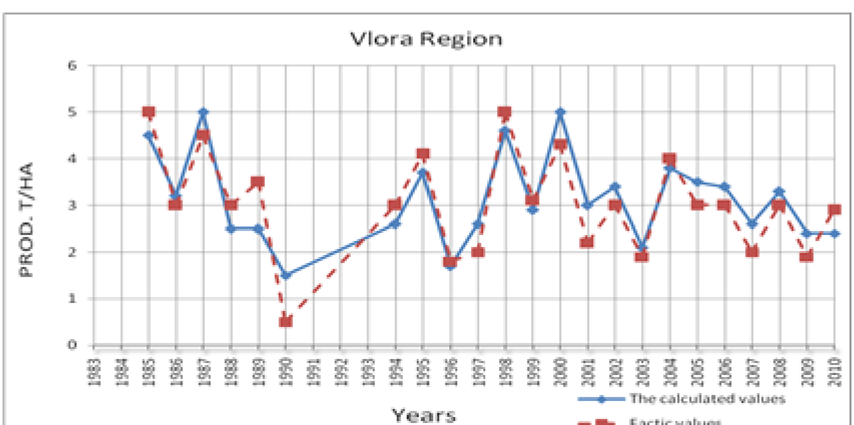

Figure 3: Yield forecasting for Olive Trees in Vlora region

Integrating aerobiological, field phenological and meteorological data is an important advance in estimating olive crop production. The reliable results confirm the validity and accuracy of the globally used Hirst volumetric traps as a tool for olive crop yield forecasting in high density olive-growing areas. Pollen content in the air can provide accurate predictions of expected olive yield up to 8 months in advance. These are an asset in enabling farmers and governments to better plan marketing strategies and define agricultural policies in Albania and the Vlora region specifically.

CONCLUSIONS

The pollen data gained from aerobiological monitoring was necessary for the construction of a forecasting model for olive plants. The method notes that only a certain amount of pollen has real reproductive in the fruit formation. In the growing and maturation phenological phases the relationship between the meteorological data became evident.

Influenced by meteorological parameters prior to the flowering period (rainfall, and to a lesser extent temperature) in Vlora region. Nevertheless, meteorological parameters during and after the flowering period have the most influence on final olive crop production. The main meteorological factor in the model was rainfall in May, followed by rainfall in June. Minimum temperatures during spring and summer were also an important consideration due to the influence of night temperature on energy collected for fruit development. And, autumn is the key season for fruit development. For this reason, different equations were constructed for different periods of the year. Results were compared with real olive crop data and estimates from the equation has a correlation coefficient about 0.77 and SE=3.0.This results confirm the validity of regression equation for forecasting of product of olive by Pollen emission and meteorological factors.

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