Biological Forum – An International Journal **7**(1): 528-533(2015)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Climate Adaptation needs to Select Suitable Crops using Papadakis

Seyed Mohammad Mahdi Torabi* and Amir Hossein Halabian**
**Ph.D. Student of Agronomy, lslamic Azad University, Tabriz, IRAN*
***Assistant Professor, Department of Geography, Payam Noor University, Tehran, IRAN*

(Corresponding author: Seyed Mohammad Mahdi Torabi)
(Received 09 January, 2015, Accepted 1March, 2015)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Accurate and simultaneous recognition of climatic factors and ecological phenomena requires use of a technique which is free from ambiguities and generalized concepts and is based on robust fundamentals. With more than 440 subcategories, Papadakis climatic classification which emphasizes on the role of ecological factors has the aforementioned advantage in spite of its particular complexities. In this study, daily temperature data over a period of 10 years Climate adaptation needs to select suitable crops using Papadakis. Calculation and agro-climatic analysis was performed making use of Papadakis method. In this study, data of the synoptic meteorological stations in Kurdistan (daily and monthly and annual reports) were received from National Meteorological Organization. This research is descriptive statistic. Data analysis is performed using Papadakis method. Evaluation of agro-climate of the area, based on Papadakis thresholds, show that northern and central parts of the province have similar conditions in terms of winter and summer cultivation, which means oat in winter type and cotton in summer type. Southern and eastern parts of the province have identical condition, as well; meaning corn in summer type and wheat in winter type.
Keywords: Climate, Papadakis, Kurdistan province

INTRODUCTION

Among different factors influencing agricultural production, weather conditions is the most variables in natural environment that human is not able to control them, except in small scale with high cost. Lack of attention to capabilities of climate and traditional cultivation of agricultural Products has been resulted to low changing yield and even the destruction of crops in some years. Agro climatology assesses interaction relationship between climatic and hydorologic factors with agriculture. The aim of agro climatology is the use of climatic information in order to improve farming practices and increment the quality of agricultural products (Mohamadi, 2006). One of the basic ways for developing and progressing of country is the optimal use of land in accordance with their ecological conditions (Farjzadeh, 2002). It is necessary to determine the agricultural climatic regions in order to identify the existing problems and issues associated with climate and agriculture. Climatic classification system refers to a set of rules through which the regions with common characteristics can be differentiated and homogenous regions can be categorized together (Hojjatizadeh, 1993), Papadakis has great contribution in this field. Papadakis (1961) based his climatic classification on the severity of the winter, the warmth of the summer, seasonal distribution and access capability to moisture. Papadakis's classification method and his research in climate, agriculture, water, soil and ecological phenomena have been gradually developed in 1975. Azizi *et al.,* (2005) have evaluated the diversity and Iran's agricultural potentialities by use of Papadakis's method. Mohmadi *et al.,* (2005) have assessed the climatic conditions of date palm cultivation in Golestan province. This research shows that Golestan province is suitable for cultivating of early ripen date palm. Hoden *et al.,* (2004) in a study using temperature and precipitation in connection with statistical techniques and providing simulation models have done climate zoning of agricultural crops in Irland. The results of research show that each area is suitable for a crop in accordance with climate. The intent of the present study is to Climate adaptation needs to select suitable crops using Papadakis East Azerbaijan Province.

MATERIALS AND METHODS

In this study, the minimum and maximum daily temperature during the period of 2001-2011 and the average monthly temperature data over the period of 1986-2011 from synoptic stations of Kurdistan province have been used (Kurdistan Province Meteorological Bureau, 1986-2011) Table 1.

Table 1: Characteristics of Kurdistan Province Meteorological Stations.

Statistical period	Altitude (m)	Longitude (degrees and minutes)		Latitude (Degrees and minutes)		Station
2001-2011	1883.4	47	37	35	53	Bijar
2001-2011	1373.4	47	0	35	20	Sanandaj
2001-2011	1522.8	46	16	36	15	Saghez
2001-2011	1286.8	46	12	35	31	Marivan
2001-2011	1379.7	46	39	34	43	Kamyaran

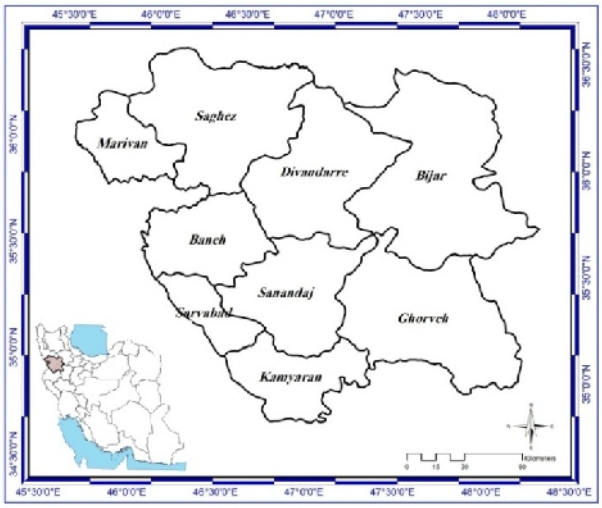

Fig. 1. The region under study.

A. Papadakis classification method

In order to classify the agricultural climate of studied area using Papadakis method, data of selected stations in the study area throughout the statistical period of 10-year (2001-2011) was used; including the average minimum and maximum monthly temperature, the absolute maximum and minimum monthly temperatures, monthly and annual average temperature and precipitation. To evaluate this method, first, based on thermal thresholds defined in related tables, winter and summer types were determined for each station. Then, having the winter and summer conditions, temperature regime for each station was extracted from the appropriate table. To determine the amount of humidity regime for each station, first, monthly potential evapotranspiration according to equation (1) are calculated. The simplest method for calculating evapotranspiration is a relation that is provided by Papadakis. This equation is as follows.

$$E = 0.5625 (ema- emi-2) eee \quad (1)$$

In this equation, emi-2 and ema are the saturation vapor pressure according to the max and min monthly temperatures, respectively, which could be obtained from Papadakis table. Papadakis constant is 0.5625. Then, Humidity Index (HI) is determined based on the ratio of monthly and annual precipitation to potential evapotranspiration(R/E). In stations which have a humid period (R<E), leaching index (LN) was calculated in order to determine the humidity conditions of months. Months of a year were categorized based on the relationship between precipitation, evaporation, and water stored in the soil into three types (wet, dry, and middle) that can be obtained from the following equations:

$$\text{Dry pet } 50\% < R + WS \quad (2)$$
$$R + WS > 500\% \text{ per middle} \quad (3)$$
$$R > \text{pet wet} \quad (4)$$

In the above equations, precipitation, soil stored water and potential evapotranspiration are introduced with R, WS and pet, respectively. Leaching index is calculated according to equation (5) and equation (6):

$$Ln = (R + WS)-E \text{ idle period} \quad (5)$$
$$Ln = \Sigma(R-E) \text{ Wet period} \quad (6)$$

Next, using the defined indices and thresholds, the type of humidity regime for each station is determined. Details of the parameters used in this method with the climatic characteristics of various types of climate in selected stations with corresponding codes are presented in related table.

Table 2 : Main climate groups in Papadakis method.

Humidity Regime	**Thermal Regime**	**Main Groups**
HU, Hu, MO, Mo, mo	EQ, Eq, TR, Tr, tr, Tt, tt	1 - Tropical
HU, Hu, MO, Mo, mo	TF, Tf, tf, An, an, aP, ap, aF	2- Tirafria
da, de, di, do	No limitation, with emphasis on humidity regime	3- Desert
HU, Hu, MO, Mo, mo	Ts, SU, Su	4 - Subtropical
St, Si, Mo, mo	PA, Pa, pa, TE, MA, Ma, ma, SU, Su	5- Pampin
ME, Me, me	No limitation, with emphasis on humidity regime	6- Mediterranean
HU, Hu	Mm, MA, Ma, ma, TE, Te, te, Pa, pa	7- Marine
HU, Hu, Mo	Co, Co, Co	8- Continental humid
St, Si, Mo, mo	Co, Co, Co, Po, Te, te	9- Steppe
Thermal regime governs	Po, Po, Fr, fr, AL, al	10- Polar

Table 3: Different types of Mediterranean and desert climate in Papadakis Method.

Humidity Regime	**Thermal Regime**	**Climate Type**
		6- Mediterranean
ME, Me	SU, SU	6-1. Subtropical
ME, Me	MA, Mm	6-2. Marine
ME	Ma	6-3. Marine Cold
ME, Me	Tr	6-4. Tropical
ME, Me	TE	6-5. Moderate
ME, Me	Te, te, Po, Pa	6-6. Moderate cold
ME, Me	Co, Co, Co	6-7. Continental
Me	SU, SU, Tr, tr, MA	6-8. Semi-arid subtropical
Me	Co, Co, Co, TE, Te, te	6-9. - Semiarid continental
		3- Arid
Da, de, di, do	EQ, TR, tr	3-1. Tropical hot
Da, de, di, do	TS, Su	3-2. Subtropical hot
Da, de, di, do	Eq, Tr, tr	3-3. Tropical cool
Da, de, di, do	SU, MA, Mm	3-4. Subtropical cool
Da, do	Tt, tt, TF, tf, An, an	3-5. Continental Antarctic
Da, de, di, do	Co, Co, Co, te	3-7- Continental
Da, de, di, do	PA, TE	3-8. Pampin
Da, de, di, do	Pa, pa	3-9. Patagoni

RESULTS AND DISCUSION

A. Evaluation of agro-climatic potentials of the region with Papadakis method

In order to study the diversity and agro-climatic classification of the region, Papadakis method has significant capabilities. Therefore, according to the selected station's data and the defined threshold in Papadakis method, agro-climatic potentials of study area is evaluated and calculated.

B. Winter Conditions

In this method, based on winter temperature and sensitivity and stability of plants to coldness, six different thermal categories is considered, including: equatorial products, tropical products, tropical products, citrus, oats, wheat and spring crops.

Thermal conditions in equatorial class are desired for growing oil palm and caoutchouc. But although the tropical class has no frost season and is in possible frost citrus class and finally in the last thermal class, winters are too severe that all products are cultivated in springs. Table (4) shows winter types and their temperature ranges, according to their ecological characteristics.

To determine the temperature classes, some climatic variables such as absolute average, maximum and minimum temperature of the coldest month are used. In fact, these variables determine the temperature drop threshold. According to Papadakis method thresholds and climate data, stations of Tabriz, Harris belong to oat class (cooler AV) and Ahar and Malekan belong to wheat (TI hotter) class.

Table 4: Temperature condition of selected stations for their winter type according to ecological characteristics.

Ecological Characteristics	Average maximum temperature of the coldest month of the year	Average minimum temperature of the coldest month of the year	The minimum temperature of the coldest month of the year	Winter type	Station
Winter, ideal for crops such as barley, but not appropriate for citrus.	-18.92	-7.96	2.95	Oat, av	Tabriz
Winter, ideal for crops such as barley, but not appropriate for citrus.	-6.31	-0.65	8.31	Oat, av	Haris
Warm enough for winter wheat, but not good for the barely	-20.77	-8.67	1.17	Wheat, TI	Ahar
Warm enough for winter wheat, but not good for the barely	-16.12	-6.88	2.48	Wheat, TI	Malekan

C. Summer conditions

According to summer temperature conditions, 9 thermal classes in Papadakis method are considered. Based on the thermal potentials and climatic conditions, these classes are as follows: cotton, coffee, rice, corn, wheat, taiga, tundra, etc. The required criteria for defining the summer conditions include: the length of the frost-free season, the average maximum temperature in the warmest month of the year and the warmer months. Frost-free season length is classified to three modes: minimum, available and n average of maximum average temperature. This classification is based on monthly average of absolute minimum temperatures. The basis for minimum, available and average is 7, 2 and 0°C, respectively. These indices and thresholds of determination of summer type are set for the following reasons: various thermal requirements of crops and natural vegetation to yield and grow in response to ecological and physiological characteristics. Table (5) shows the types of summer and their thermal range (in °C). The results of study of summer conditions based on thresholds and thermal ranges of Papadakis method for stations within the province is as follows. Sanandaj Station belongs to cotton (G) warmer class and Bijar station in cotton (g) cooler class. Saghez and Marivan stations are placed in the class of corn (m). According to climatic data and thresholds of Papadakis in summer conditions, all stations have the suitable agro-climatic conditions for the cultivation of crops such as cotton and corn (type G , g and m) and other crops that require hot and dry weather.

Table 5: Temperature condition of selected stations for their summer type according to ecological characteristics.

Ecological Characteristics	Average maxi temperature of the hottest month of the year	Average maxi temperature id n hottest months	Frost-free season, Months	Summer type	Station
Sufficiently long hot summer for cotton	24.54	N=6>25	Min 5>4.5	Cotton g	Bijar
Sufficiently long hot summer for cotton	33.85	N=6>25	Min 5>4.5	Cotton g	Sanandaj
Rice is not the main crop	25.23	N=6>21	Available >4.5	Corn m	Saghez
Rice is not the main crop	25.11	N=6>21	Available >4.5	Corn m	Marivan

D. Temperature and humidity regime

Study of the thermal regime for all selected stations in Kurdistan Province is as follows. The either belong to continental (co) class and in terms of humidity, Sanandaj and Saghez stations belong to belong to dry Mediterranean class and Bijar and Marivan stations to the Mid dry Mediterranean class.

Table 6: The calculated indices in Papadakis method.

Humidity regime	Thermal regime	Winter type	Summer type	Frost-free season	Evapotranspiration	Annual temperature	Annual precipitation	station
ME	Co1	av	G	n>4.5	874/69	22/65	414/8	Bijar
Me	Co1	av	G	n>4.5	1538/00	22/24	464/74	Sanandaj
Me	Co1	av	G	n>4.5	835/88	21/29	449/29	Saghez
ME	Co1	av	G	n>4.5	743/06	21/59	515/46	Marivan
Climatic class	Leaching	Humidity index		Dry months	Mild months	Humid months		station
6-7	202/23	0/51		May to October	November	December to April		Bijar
6-7	95/08	0/30		May to October	November to April	November to March		Sanandaj
6-7	217/54	0/54		May to October	May	November to April		Saghez
6-7	287/48	0/69		May to October	May	November to April		Marivan

CONCLUSIONS

Weather and climate are the most important parameters which affect on growth and development of plants and are the non-control and effective factors in agriculture. Threshold tolerance of plants is limited to these climatic parameters and fluctuation of these parameters has significant effect on agricultural products directly and indirectly. Climatic conditions are the most important variables in the production of agricultural products. With awareness of climate and agricultural potential climatic zones can be more efficient resource use. Areas suitable for cultivation of a wide range of the world's most important crops will shift as a result of climate change. Overall, suitable areas will increase, but most affected by loss of area will generally be regions that are already struggling from the impacts of irregular and extreme climate events. To minimize the impacts of climate and other environmental changes, it will be crucial to breed new varieties for improved resistance to abiotic and biotic stresses.

Plant breeders need to increase their attention to breeding varieties that have greater tolerance to local abiotic stresses such as drought, flooding and extreme temperatures as well as continuing to breed for resistance to pests and diseases. Analysis of weather and reviewing the impact of these factors contribute to agricultural crops in the agricultural sector managers Favorable or unfavorable weather events are likely to be able to accurately estimate the later stages of plant development. Calculation and agro-climatic analysis was performed making use of Papadakis method. In this study, data of the synoptic meteorological stations in Kurdistan (daily and monthly and annual reports) were received from National Meteorological Organization. This research is descriptive statistic. Data analysis is performed using Papadakis method. Evaluation of agro-climate of the area, based on Papadakis thresholds, show that northern and central parts of the province have similar conditions in terms of winter and summer cultivation, which means oat in winter type and cotton in summer type. Southern and eastern parts of the province have identical condition, as well; meaning corn in summer type and wheat in winter type. Study of the thermal regime for all selected stations in Kurdistan Province is as follows. The either belong to continental (co) class and in terms of humidity, Sanandaj and Saghez stations belong to belong to dry Mediterranean class and Bijar and Marivan stations to the Mid dry Mediterranean class

REFERENCES

Hodjatizadeh, Rahim (1992). Climatic Zonation of Iran, Master Thesis in Geography, University of Tehran.

Ramezani, Bahman (1997). Agricultural Climatology, Iran's Meteorology Organization (Gilan University's Publications).

Azizi Qasem (2001). Cultivar Classification of Selected Climatic Stations in Iran using LITIN ESXES Method. *Geographic Research,* **41**: 37-51.

Alijani, Bohloul and Kaviani, Mohammadreza (1992). Principles of Climatology (SEMAT Publications).

Farajzadeh Manowchehr and Taklobighash AbbasS (2001), Agroclimatic Zonation of Hamadan Province using Geographic Information System. *Journal of Geography Researches*, **4:** 93-105.

Fesharaki, Paridokht (1990), *Glossary and Terminology of Natural Geography*.

Kuchaki, Avaz and Khazanehdari, Leili (1997). Climate and Agricultural Geography. *Quarterly of Geographic Researches,* **40**: 56-71.

Quanta (1982), Agricultural Meteorology Studies (Iran's Meteorology Organization) (Gilan University's Publications) 1.

Burgos (1995). World Trend in Agro Climatic Surveys (UNESCO).

FAO (1993). Agro-ecological assessment for national planning: the example of Kenya.

Gates D (1993). Climate change and its biological consequences (Sinauer Assocates Inc) 150-161.

Kenny G et al., (2000). Investigating climate change impacts and Thresholds. *Climate change*, **46**: 91-113.

Lambers RH and et al., (2001).Vegetation pattern formation in semiarid grazing system. *Ecology*, **82:** 50- 61.

Lenka D (1998). Climate, weather and crop in INDIA (Kalyani publishers).

Mavi HS (1990). Introduction to agro meteorology (oxford and IBH publishing co). 211-219.

Minnen J *et al.,* (2000). Deriving and applying response surface diagrams for evaluating climate change impacts on the crop production. *Climate Change*, **46:** 317-338.

Papadakis J. (1996). Climate of the world and their agricultural potentialities, Buenos Aires.pp.1-48.

Parry M.L. (1998). The impact of Climate variations on agriculture (Kluwer Academic Publisher) 473-482.

Prentic K. (1990). Bioclimatic distribution of vegetation for GCM studies, *Geophysics research*, 1181-11830.

Prentic K. and Fung L. (1990). The Sensitivity of terrestrial carbon storage to climate change. *Nature*, **346:** 48-54.

Sivakumar M. and et al., (1993). Agroclimatology of West Africa: Niger (ICRISAT) 5-25.

UNESCO (1995). Agroclimatological method, *proceeding of the reading symposium* 211-220.

Yates D. et al., (2000). Comparing the Correlative Holdridge Model to Mechanistic Biogeographical Models for Assessing Vegetation Distribution Response to Climatic Change. *Climatic Change,* **44**(1-2) 59-87.