Zagazig J. Agric. Res., Vol. 48 No. (1) 2021 111-122

Soil Science and Agricultural Engineering

Available online at http://zjar.journals.ekb.eg
http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

INFLUENCE OF TEMPERATURES RISE OVER 48-YEARS ON SULAYMANIYAH AGROECOSYSTEM STRUCTURE AND NEMATODES DISTRIBUTION USING GIS APPLICATION

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Received: 01/12/2020 ; Accepted: 30/12/2020

ABSTRACT: From a studied to collect data for temperature degrees during 1973 until 2019 there is clear evidence that show climate change is happening in our region. The collected data showed that the average annual temperature rate has raised by almost 1.3°C, the average of warmest year for this period was recorded in 2010 and it was 21.55°C. In 2016, average temperature degree was high 20.3°C as the global worm rising the lowest temperature in this period was 16.2°C recorded in 1992. Since 1973 until 1985 the average temperature was 18.39°C and since 1986 until 1998 the average temperature raised to 18.79°C, then since 1999 until 2010 the average temperature raised again to 19.93°C but in period 2011 to 2018 the average temperature raised to 20.09°C. The difference between warmest monthly average temperatures and the coldest month of the year or annual range in 1988 was the highest and valued 31.9°C while in year 1973 was the lowest (19.6°C) but the rate for the period 1973 to 2018 was 27.9°C. The *absolute* annual temperature range or differences between the maximum absolute temperature and the minimum absolute temperature during a year was obvious like in 1973 was the highest (53°C) and in 1987 was the lowest (35°C). Diurnal temperature variation or the daily difference between the maximum and minimum temperatures was limited in winter months almost recorded 6 - 9°C, but in summer months the ranges is bigger almost reported 15 - 18°C. Over these years specially from (2008 -2019) soils that affected with plant pathogenic nematodes increased dramatically in the study area witch was within 10 km^2 because of rising temperatures degrees and need to use greenhouses instead of open field cultivation, these greenhouses numbers influencing on agroecosystem structure for a long terms. From this investigation, and to control plant pathogenic nematodes in the infested greenhouses, farmers used kinds of chemical pesticides that cause damages to the soils and the yields as well as changing agroecosystem structure. Agroecosystem structure for the study area has been changed relatively because of increasing the numbers of greenhouses that got almost 7000 greenhouse causing imbalance in agroecosystem by using a huge amount of water (125 m^3/greenhouse).

Key words: Climate changes, rising temperature, agroecosystem stricture, Plant-Parasitic Nematode

INTRODUCTION

Among the many global exchange factors that contribute to non-linear responses to ecosystems and sudden shifts, climate change in particular is likely to push ecosystems across borders. Experiments have shown that climate change can lead to changes in the ecosystem. Transformations caused by warming in species composition in grassland are widely observed (**Yang *et al.*, 2011**). Warming above 1.5°C is expected to significantly increase the likelihood of reaching critical turning points for ice sheets in Greenland and Antarctica (**Climate Analyzes, 2017**) as Greenland's ice sheet faces an irreversible drop of about 1.6°C to warming (**Hare *et al.*, 2016**). While there are some uncertainties regarding the turning points, it is clear that

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limiting the rise of temperatures to less than 1.5°C will lead to a rise in the sea level to less than one meter and that rising temperatures above this level threatens to raise the sea level to several meters over the coming centuries. An increase in shrubs and grass-like plants can reduce the competitive performance of other plant species and thus change the competitive hierarchy within society (**Niu and Wan, 2008**). Net primary productivity. Ecosystem state shifts can significantly affect ecosystem functions, including changes in net primary productivity, water and food recycling, regional climate regulation, and food interactions (**Zavaleta, 2006**).

Recent research in agricultural ecosystems indicates that winter climate changes may lead to lower soil levels C and isolation of the C ecosystem (**Senthilkumar *et al.,* 2009**). Global warming can have adverse effects on plant growth.

From a long-term viewpoint, however, warming temperatures in the atmosphere will drive major crop production sites. Water shortages caused by global warming will be the biggest problem for crop production (**Nakicenovic *et al.,* 2000**). Plants mainly depend on sufficient fresh water, and agricultural water accounts for 70% of water use worldwide. As temperatures rise, evaporation increases water sources and precipitation decreases, arid regions will become more ruined. Generally speaking, entire crop production will be affected by global warming, leading to food shortages worldwide (**Singh and Sontakke, 2002**).

Photosynthesis is one of the most physiological processes sensitive to stress when hyperthermia. Reproductive development is more sensitive than the vegetative development of high temperatures, and temperature sensitivity varies between crops (**Singh *et al.,* 2001**).

The components of the agroecosystem are highly sensitive to changes in climate, especially to severe weather events, low soil moisture, temperature changes and an increase in carbon dioxide in the atmosphere. It will also affect groundwater replenishment patterns and epidemic transpiration rates (**Allen *et al.,* 1994**).

Results reported that climate change scenarios without the physiological effects of CO_2 cause a decrease in the estimated production. Greenhouse gases such as CO_2, CH_4, and N_2O are directly related to agriculture (**Aggarwal, 2000**).

The global warming potential (GWP) of CH_4 is twenty times and the potential for nitrous dioxide is 300 times that of carbon dioxide, while the physiological effects of CO_2 mitigate the negative effects (**Warrick, 1988**).

Cure and Acock (1986) reported that, controlling environment of cultivation has enriched the information about temperatures degree that effected increasing or decreasing on the agroecosystem practices. The impact of temperature degrees is more complicate with lower production.

Increasing temperatures and interacting with changes in water systems and water management that affect crop productivity and sustainability in ecosystems. Likewise, changes that interact constructively should take into account negative events, especially torrential rains, with direct consequences such as the loss of irrigated areas or agricultural land, due to the high or frequent floods and droughts. Changes in the water system will affect the water availability of plants and will affect yields, increase their density and parasitoid levels with nematodes, due to the positive effects on the plant's entire biomass (**Wessolek and Asseng, 2006**).

Increasing temperatures are expected to enhance plant growth, providing a greater food source for nematode but also increasing the whole ecosystem. Temperatures also effect on some plants stages like rapid of germination, flowering of plants (**Goudriaan and Zadoks, 1995**).

Higher CO_2 levels lowered the numbers of bacterial feeders, increasing fungal feeders and predators in forest (**Neher *et al.,* 2004**). Air pollutants effect on nematodes through changes in the physiology of the host plant. Synergistic interactions between ozone or SO_2 and *Meloidogyne incognita* were observed on tomato, as higher levels of foliar damage were found on nematode infested plants (**Khan and Khan, 1997**). Nematodes reaction to rising CO_2 levels is complex, depending on trophic groups: no effect was reported on nematodes from grassland soil (**Freckman *et al.*, 1991**), but numbers decreased in cotton rhizosphere (**Runion *et al.*, 1994**).

Objectives of the study

The objectives of the present study aims to determine the general trend of temperature and study the effect of the change in temperature rise on increasing infection of root-knot nematodes (*Meloidogyne* spp.) in Sulaimaniyah Governorate, Iraq.

MATERIALS AND METHODS

The study used the inductive and inferential method in treating climate data,by studying, analyzing, and categorizing the monthly averages of temperature, and deriving the results,the study used the descriptive approach in describing the rise in temperature, determining the factors that cause it, and describing the environmental effects resulting from it. The study also used a number of statistical methods to collecting data’s in excel sheet to get the average annual temperature, the absolute annual temperature range, diurnal temperature variation.

The study area was in Sulaimaniyah Governorate. City of Sulaimaniyah is located in the northeastern part of Iraq. It characterized by the general nature of its surface. It is mountainous and is surrounded by valleys and some small plains. The city is located on the western slopes of the Azmur Mountains that located between longitude 35^{o}.49'. 00" N. and latitude 45^{o}.25'.00" E. The city is surrounded by several mountain ranges from north-west to south-east.Sulaimaniyah is providing on sloping land 3.5%. The northern end of the city is 885m above sea level and southern end is 800m. above sea level.

Based on climate classifications carried out by researchers and specialists in this field the climate of the city can be considered as a temperate climate or (the Mediterranean climate of the mountain) and its most important climatic characteristics are:

- The annual average temperature is 18.74°C.
- As for the wind and as shown in the wind rose of the city, the prevailing winds are (North-East and usually very fast). Rainfall mainly in winter and spring, while there is no rain in the summer, more annual Rainfall recorded in 2018, reaching 1273.80 mm. The average daily amount of solar radiation reaching the Sulaimaniyah station is 989.4 kcal/cm^2/day. It is possible to say that there is moderation in the solar radiation in the general northern region in general and Sulaimaniyah in particular due to the high clouds and relative humidity. Daily vertical radiation rate that reaches the northern region equivalent to 5-6 kWh /m^2 and 6-6.5 kWh /m^2 for the central and southern region.
- The average daily brightness of the sun below in February (4.7) hours/day and the maximum in July (12.6) hour / day, the annual rate of this period is (8.33) hours/day, less than the total rate of energy saving (the period of sunshine) 8.8 hours per day.

The biological assessment of the city of Sulaimaniyah illustrates the following:

- In terms of rainfall, it is noted that high rates of rainfall fall annually, as the annual rate of 1273.8 mm.

Survey of root-knot nematode infection was made in the greenhouses in an area contain at least 4000 greenhouses. Studying types of vegetables that planted in these greenhouses.

RESULTS AND DISCUSSION

Understanding How Temperatures Increased by 1.5°C

Fig. 1 shows the changes in annual averages temperatures and the increase of disorder in climatic patterns, year of 2010 was the highest year in average annual temperature of 48 years since 1973-2019 on recorded with increase get 1.5°C and 1999 was high also with difference’s increase getten average of 1.5°C if making a trendline throw these years the heat increased from 18°C to 19.5°C almost. From Table 1 the overlap between temperature rise and effect of that on agriculture and type of plant cultivate has become crucial to understanding the role that region warming plays in contributing to agriculture and mitigating its effects (**Gaasland, 2003**). Increasing or decreasing Sulaimaniyah air temperatures impact on plant distribution and

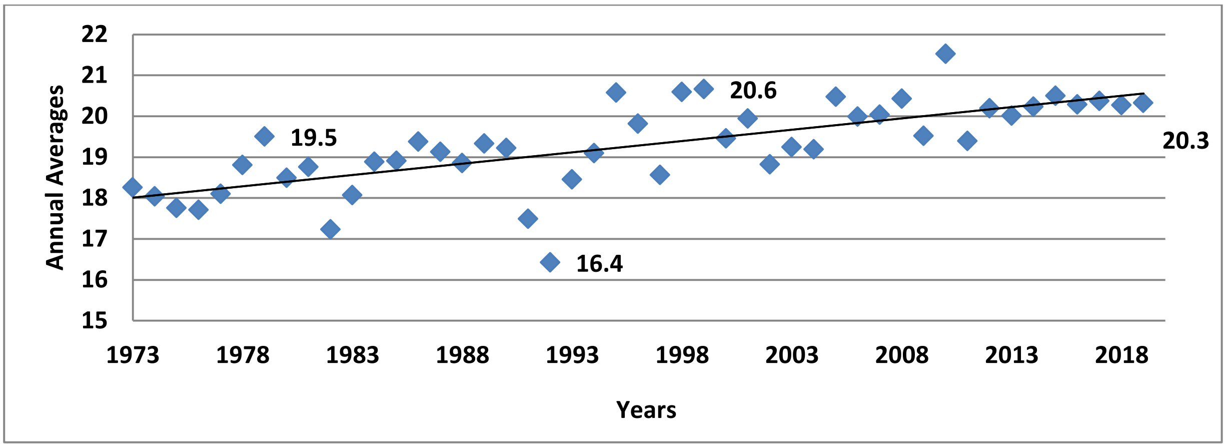

Fig. 1. Average annual temperatures degree (°C) during 48 years (1973-2019)

__Source__: Directorate of Meteorology and earthquakes in Sulaimaniyah, Iraq

productionas well as management drought conditions (**Battisti and Naylor, 2009**). Warming also could make changing in the resistance of vegetable's to specific diseases or by increasing disease of living organisms by mutation caused by environmental stress (**Gregory *et al.*, 2009**).

In Sulaimaniyah region the absolute temperature have a clear range between the maximum and minimum degree (Fig. 2). Data's recorded in years like 1972, 1975, 1981, 1987, 1988, 1998, 1999, 2008, 2010, 2018 shows differences between the maximum absolute temperature and the minimum absolute temperature during the year that affect agriculture by changing the length of the growing season, and crop distribution (**Chakravarty and Mallick, 2003**).

Maximum and Minimum Temperature Directions

Average of minimum and maximum temperature both have their own significance effects in the growth and development of plants during life cycle. The highest maximum temperature year are found in 1987 (Figs. 3 and 4) while the lowest temperature year were in 2019. During these 48 years the maximum temperature increased by an average of 1.5°C. This a clear evidence of strong changing climate in our region by increasing temperature in a way ecosystems have responded to these changes.

Crop production suffers in our regions where changes in temperature will further stress the already limited productive (**Müller, 2009**).

Because of the temperatures getting higher also grow seasons have become unstable that's leads to droughts condition which affect the quality of yields (**Howden *et al.*, 2007**).

Annual Averages for March Month as an Individual Months

March month is an impotent for agriculture in our region, so it considerate in the coldest months and the most worm as well as founding the trendline for all months during 1973 – 2019 the coldest March month were 3.95, 4.3 and 4.7°C, respectively in years 1992, 1987 and 2019, warmest March months degree were 21.95, 21.35 and 19.45°C in years 2008, 2018 and 1997. The general trendline for March annual average temperature degree for past 48 years was increasing in a way that clearly shows how temperatures rise in our region, environment like that will effect on quality and quantity of agricultural productivity, changing in quantity of water that use in irrigation or other cultivation process (**Wolfe *et al.*, 2008**).

Trendline for the records in Fig. 3 shows how worm in March month increase about 1.5°C and that increase of effecting by pests and disease as well other stress sucrose on the yield that decreased by about 30% (**Souza *et al.*, 2008**) as well as the morphology of transplanting such as size, color, mild water stress have effected clearly because of the increase in temperature in this month (**Inman-Bamber *et al.*, 2009**).

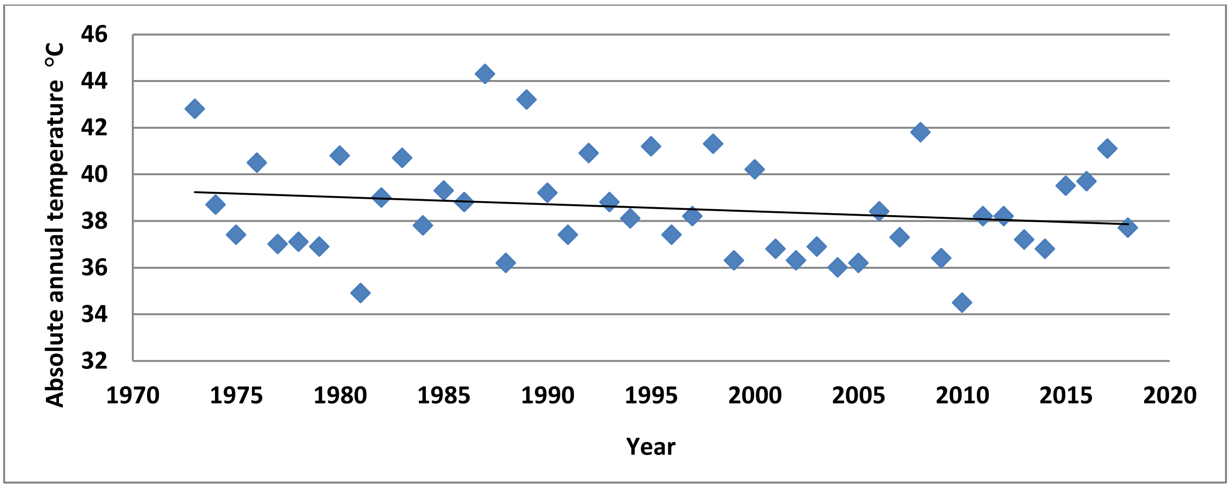

Fig. 2. Absolute annual temperatures degree (°C) during 48 years (1973-2019)

Source: Directorate of Meteorology and earthquakes in Sulaimaniyah, Iraq

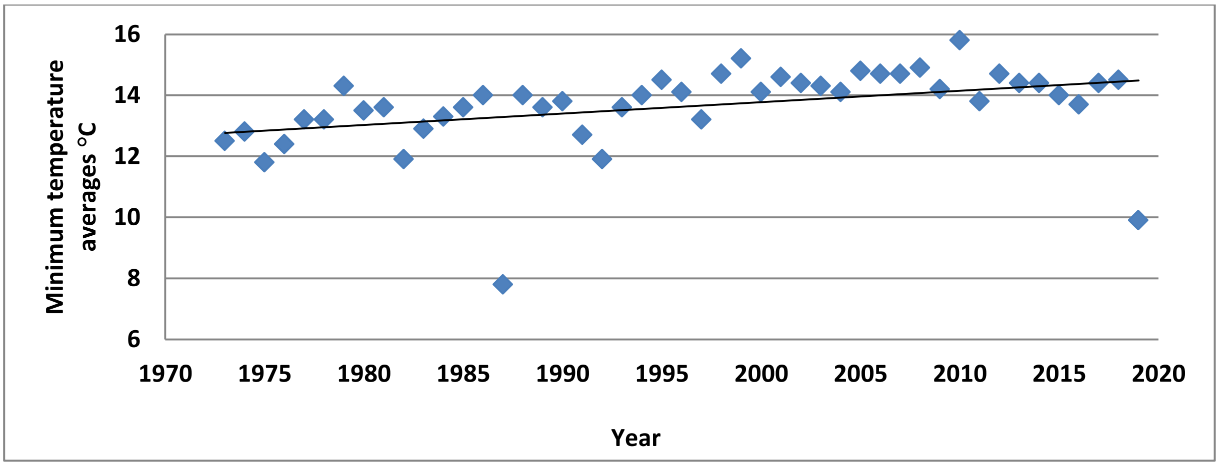

Fig. 3. Annual minimum temperatures degree (°C) during 48 years (1973-2019)

Source: Directorate of Meteorology and earthquakes in Sulaimaniyah, Iraq

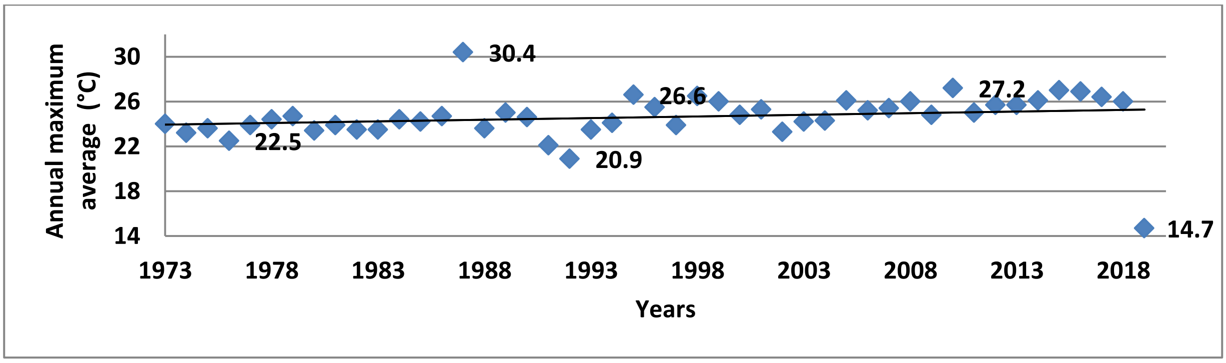

Fig. 4. Annual maximum temperatures degree (°C) during 48 years (1973-2019)

Source: Directorate of Meteorology and earthquakes in Sulaimaniyah, Iraq.

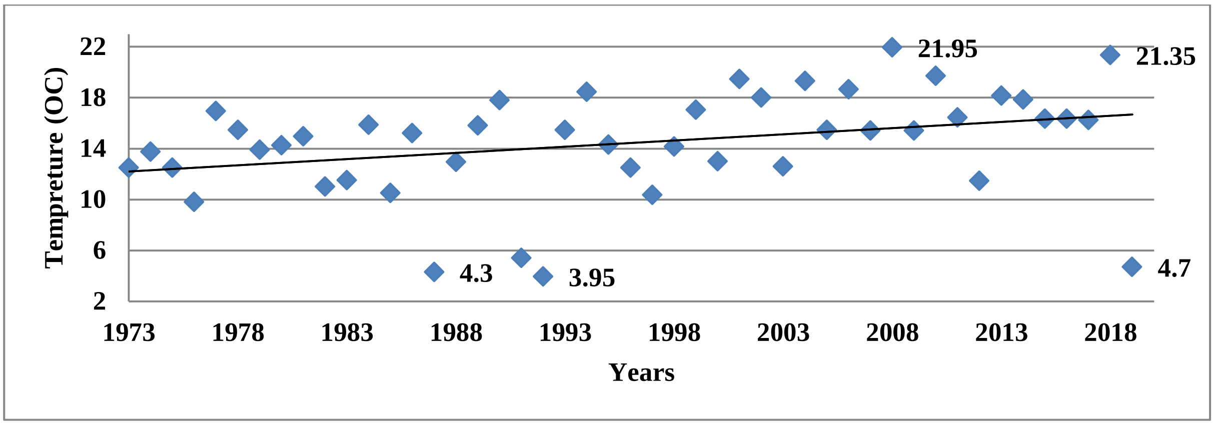

Fig. 5. The annual averages for March month during (1973 – 2019)

Source: Directorate of Meteorology and earthquakes in Sulaimaniyah, Iraq.

Annual Averages for August Month as a Heating Month in the Season

Trendline in Fig. 6 for heating degrees recorded for August months since 1973 until 2019 shows increasing in the temperatures from 31.5°C average to 33.8°C average. Continuing in rise temperature cause drought in the ecosystem as well the huge range between day night temperature that reach (20°C) and decreasing air humidity lead to dry air and wide speared drought because of narrowing the vegetation cover areas (**Chitwood, 2002**).

Temperatures and soil temperature as a results affects many nematode activities such as egg hatching, nematode distribution, and their ability to survive It also affects the plant host and thus the nematode, nematode to remain in an active state, a thin membrane of water must be available to cover it, and a sufficient amount of oxygen to breathe. These two requirements are usually met in most agricultural soils at a humidity level of 40-60% of the field capacity. The fluctuation of soil moisture due to irrigation water is one of the main factors affecting nematode density in the soil (**Sikora and Fernandez, 2005**).

Survey of some Important Cultivation Locations in Sulaimaniyah Agroecosystem

Site description

This area is a wide plain with slightly slope topography called Bazian Plain. It's contain 6 Watersheds and 14 micro-catchments (**Barzinji, 2013**).

In 24 locations (villages), select some greenhouses cultivated with vegetables (Cucumber, Tomato, and Pepper) to take soil samples (25 cm depth) for nematodes analysis.

Nematode egg masses were isolated and counted from soil as indicated in Table 1.

After 2007, excessive use of greenhouses increased with the relative increase in temperature rates, which led to an increase greenhouses gain heat during the day with the solar radiation entering these greenhouse and turn into thermal energy when in contact with plants and soil. This huge areas of using plastic greenhouses contributed to increased the air temperature throw emersion's gases especially CO_2 causing the spread of types of diseases, insects and plant parasite like nematodes (**Varshney *et al.*, 2011**).

The results of this study show that type of crop plays a major role in increasing nematodes distribution, the cucumbers and tomato plant roots are more affected by root-knot nematodes compering to other vegetables (Table 2).

Also, the nematodes in the pepper infested soils responses to the changes of hydrologic cycle as a result to the changing climate, rising temperature degrees when these worms are transported from drought soils to the wet soil in the greenhouses that being irrigated regularly (**Hoeksema *et al.*, 2000**).

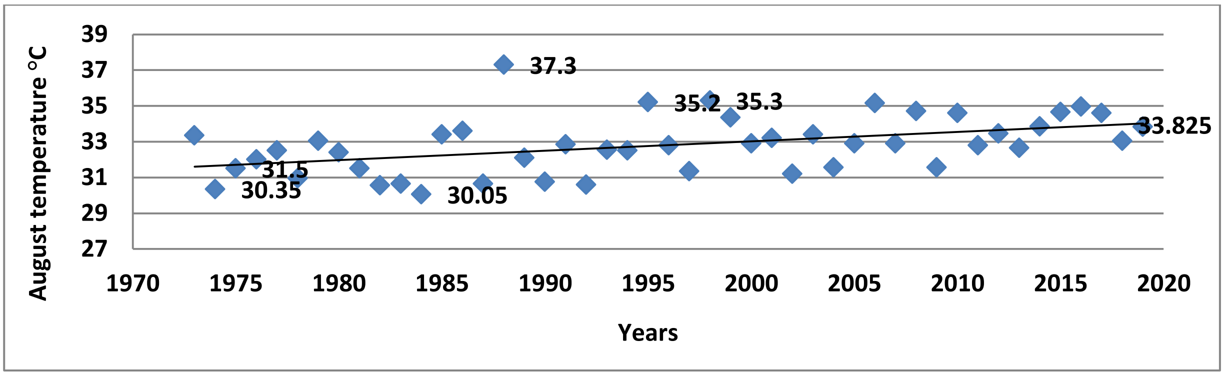

Fig. 6. The annual averages for August month during (1973 – 2019)

Source: Directorate of Meteorology and earthquakes in Sulaimaniyah, Iraq.

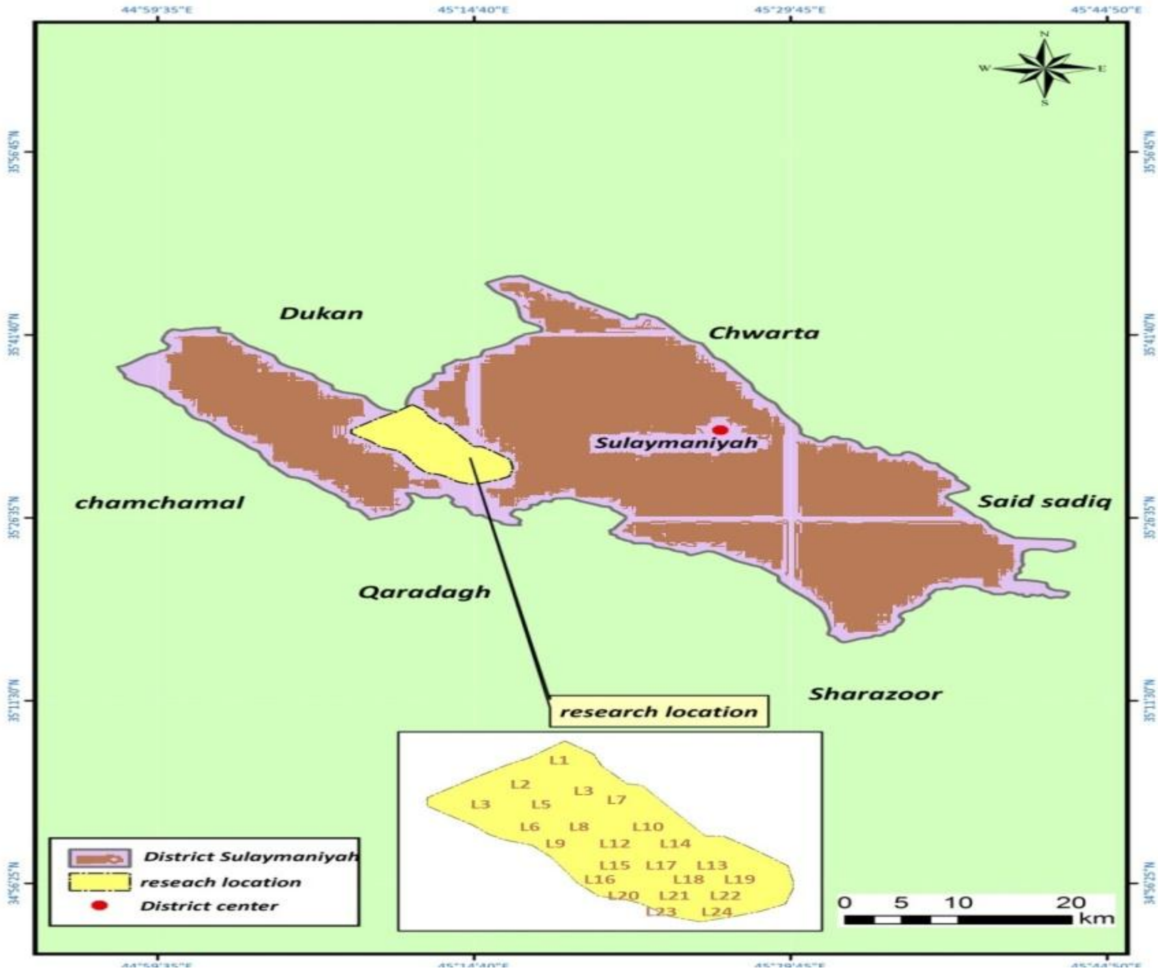

Fig. 7. Villages coordinate for survey locations in Sulaimaniyah Governorate

Study area using application of GIS (ArcGIS 10.1 program)

Table 1. Nematode analytical

No.	Tools and materials	Reference
1	20-mesh sieve (833 µm aperture)	
2	200-mesh sieve (74 µm aperture)	Howard Ferris, Departments
3	325-mesh sieve (43 µm aperture)	of Entomology and
4	Coarse sieve (1 cm aperture)	Nematology,
5	Two stainless steel bowls or plastic buckets	University of California
6	250 ml beaker, 600 ml beaker	(from **Zuckerman *et al.*,**
7	Coarse spray wash bottle or tube attached to faucet	**1981**)

Soil samples taken from these locations from depth 25-30 cm.

Table 2. Survey for root-knot nematodes (*Meloidagyne* spp.) in some locations of Sulaymaniya Governorate

Loc.	Village name	Latitude (N)	Longitude (E)	Crop	Description	No. of egg masses/root system
L_1	Bagajani	35.573129	45.179865	Cucumber	Not infected	0
L_2	Mewk	35.574642	45.170733	Cucumber	Infected	16
L_3	Bagajani	35.562523	45.153836	Cucumber	Infected	23
L_4	Koyik	35.563983	45.170733	Pepper	Non infected	0
L_5	Kani big	35.563227	45.175807	Cucumber	Infected	24
L_6	Shuwankara	35.564188	45.192795	Cucumber	Infected	20
L_7	Tuiawlia	35.559212	45.190636	Tomato	Not infected	0
L_8	Qushqaya	35.557166	45.193336	Tomato	Infected	31
L_9	Ali Bzaw	35.555679	45.180524	Pepper	Non infected	0
L_{10}	Ali Bzaw	35.554676	45.176405	Cucumber	Infected	27
L_{11}	Penjsharnma	35.540696	45.191150	Tomato	Infected	30
L_{12}	Kani Shaya	35.538872	45.217801	Cucumber	Infected	39
L_{13}	Kani Shaya	35.529785	45.204436	Cucumber	Infected	19
L_{14}	H. Sarchawa	35.525898	45.208930	Pepper	Not infected	0
L_{15}	H. Sarchawa	35.531651	45.195435	Cucumber	Not infected	0
L_{16}	Mahmudia	35.524027	45.198905	Tomato	Infected	13
L_{17}	Ziyeka	35.524583	45.221645	Cucumber	Not infected	0
L_{18}	Ziyeka	35.518852	45.222030	Cucumber	Infected	17
L_{19}	Warmizyar	35.515835	45.237502	Cucumber	Infected	21
L_{20}	Warmizyar	35.517955	45.235790	Tomato	Infected	18
L_{21}	Gawani	35.500416	45.254908	Cucumber	Not infected	0
L_{22}	Gawani	35.501443	45.254239	Cucumber	Infected	28
L_{23}	Gawani	35.508113	45.254239	Cucumber	Not infected	0
L_{24}	Latifawa	35.492244	45.231547	Cucumber	Infected	25

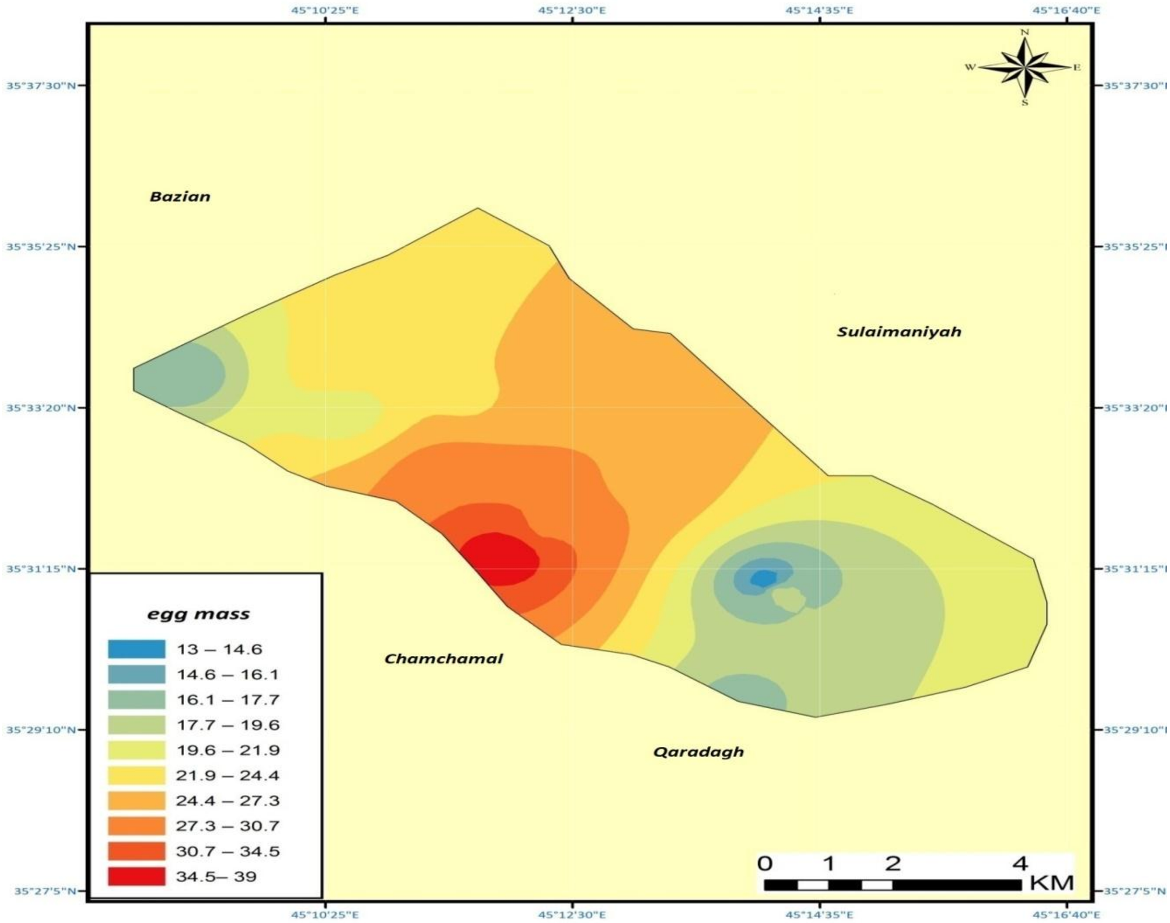

Fig. 8. Survey for nematodes egg masses distribution in Sulaimaniyah, Bazian plane

Gis map explain the distribution of egg masses in the study area (ArcGIS 10.1 program).

However, increasing heat in the plant environment cause increasing in the plants physiological activates such as heat that absorbed and the amount of heat that lost energy then the plant is heated and increase the permeability of membranes and leakage of dissolved substances from cells thus root surface become more vulnerable to the nematodes (**Chakraborty *et al.*, 2000**).

Temperatures rise and changes in cultivation environment when interacted with some human activity such as using land that affecting on crops productivity and sustainability in the study area ecosystems (**Fuhrer, 2003**).

Other impacts of climate change, such as the occurrence of floods, contributed to the increased prevalence nematodes like what happened in 2019 (**Akram *et al.*, 2020**), which led to the spread of many diseases and pests in particular nematodes (**Kardol *et al.*, 2010**).

Conclusion

A changing about 1 or 1.5°C in temperature can impact on agricultural ecosystem in Sulaimaniyah region. Agricultural crops will be more exposed to the temperature stresses caused by extreme climatic events. Warming and rising warm degree enhances the distribution of nematode. Moreover, due to increasing temperature, from our investigation many wild species of plants become extinct for example (Anchusa and Digitalis), increasing temperature degree relate to the increasing in CO_2levels having negative physiological impacts photorespiration on plant.

So Sulaimaniyah city it is comfort from heating side for humans and the assessment of areas above the level of thermal comfort to warm and warm, the temperature during the year is as follows: 45% of year it is cold.30% it is comfort for humans.15% fell warm.10% it is hot.

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تأثير الارتفاع في درجات الحرارة على مدى 48 عاما على هيكلية النظام البيئي الزراعي و توزيع النيماتودا في السليمانية باستخدام تطبيق نظم المعلومات الجغرافية

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من دراسة أجريت لجمع البيانات الخاصة بدرجات الحرارة خلال الفترة من عام 1973 حتى عام 2019، يتضح لنا بالدليل أن هناك تغيرات مناخية تحدث في منطقتنا، تشير البيانات إلى أن متوسط درجة الحرارة السنوية قد ارتفع بنحو 1.3 درجة مئوية، وقد تم تسجيل متوسط السنة الأكثر دفئًا خلال هذه الفترة في عام 2010 وكان 21.55 ^{o}م، في عام 2016 كان متوسط درجة الحرارة مرتفعًا والذي وصل إلى 20.3^{o}م مع ارتفاع درجة الحرارة العالمية. وقد سجلت أدنى درجة حرارة في هذه الفترة 16.2 ^{o}م في عام 1992، منذ عام 1973 حتى عام 1985 كان متوسط درجة الحرارة 18.39 ^{o}م ومنذ 1986 حتى 1998 ارتفع متوسط درجة الحرارة إلى 18.79 ^{o}م ثم منذ 1999 حتى 2010 ارتفع متوسط درجة الحرارة مرة أخرى إلى 19.93 ^{o}م ولكن في الفترة 2011 إلى 2018 ارتفع متوسط درجة الحرارة إلى 20.09 ^{o}م، كان الفرق في متوسط درجة الحرارة بين أكثر الشهور سخونة وبرودة في السنة والذي يعرف بالنطاق السنوي لدرجة الحرارة في عام 1988 هو الأعلى 31.9 ^{o}مبينما كان في عام 1973 أدنى مستوى 19.6^{o}م ولكن المعدل للفترة من 1973 إلى 2018 كان 27.9 ^{o}م، كانت مدى درجة الحرارة السنوية المطلقة أو الفروق بين درجة الحرارة القصوى المطلقة ودرجة الحرارة الدنيا المطلقة خلال عام واضحًا كما في عام 1973 كان الأعلى 53 ^{o}م وفي عام 1987 كان الأدنى 35^{o}م، كان الاختلاف في درجات الحرارة اليومية أو الفرق اليومي بين درجات الحرارة القصوى والدنيا محدودًا في أشهر الشتاء تقريبًا 6-9 درجة مئوية ولكن في أشهر الصيف تكون النطاقات أكبر تقريبًا 15 - 18 درجة مئوية، على مدى هذه السنوات خاصة في الفترة من 2008-2019 توسعت مساحات الأراضي التي تأثرت بالنيماتودا المتطفلة على النبات بشكل كبير حسب دراسة اجريت على مساحة 10 كيلومترات مربعة و ذلك بسبب ارتفاع درجات الحرارة والحاجة إلى استخدام البيوت البلاستيكية بدلاً من الزراعة في الحقول المفتوحة، ومن خلال هذه الدراسة اتضح ان المزارعون للسيطرة على الديدان الخيطية التي تصيب للنباتات في البيوت المحمية المتضررة يستخدمون أنواعًا من المبيدات النيماتودية التي تسبب أضرارًا للتربة والانتاج بالإضافة إلى تغيير النظام البيئي الزراعي، حدث تغيرفي بنية النظام البيئي الزراعي لمنطقة الدراسة نسبيًا بسبب زيادة أعداد الصوب الزراعية التي وصلت الى ما يقرب من 7000 صوبة زجاجية مما تسبب في اختلال توازن النظام البيئي مثل استخدام كمية كبيرة من المياه في الري 125م^3/ صوبة.

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