Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 04, NO. 02, 2019
http://www.nilevalley.edu.sd

Research paper

Effect of Ambient Temperature and Relative Humidity on Foraging Activity of Termite *Microtermes thoracalis* (*Isoptera: Macrotermitinae*) in Sinnar State, Sudan

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ABSTRACT

A field study was carried out at two experimental sites in Sinnar State during April- July 2014, to assess the effect of relative humidity and temperature on the foraging activities of termite species belonging to the Genus Microtermes in tree canopy and open areas. The first site was located at the eastern bank of the Blue Nile River (Elsuki locality- Hilatsaeed) while the second site was located at the western bank of the Blue Nile River (Abuhujar locality- Sairo). Randomized Complete Block Design with four replicates was used to perform this study. Treatments in each site are executed in an area of four plots 10×10 meter. Ten wood baits were placed horizontally along rows of 2 meters, giving a total of 400 baits per two treatments. The baits were then examined for termite damage at two weekly intervals and the number of attacked baits was expressed as percentage. The collected data was subjected to statistical analysis using Statistical Analysis System computer package. The results showed that there were fairly marked differences in the levels of infested wood baits laid in trees canopy compared to levels of infested wood baits laid in open-areas. The termites foraging activity in tree canopy is greater than that in open areas. It is worth mentioning that infestation of wood baits by termites increased as temperature decreased and relative humidity increased.

Keywords: Termites, foraging activity, *Microtermes spp*., Isoptera

تأثير درجة الحرارة والرطوبة النسبية على نشاط الأرضة *Microtermes spp.* (Isoptera, Microtermitinae) في البحث عن الغذاء، ولاية سنار، السودان

فتح الرحمن ابراهيم الصديق

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أجريت دراسة حقلية في موقعين مختلفين من ولاية سنار في الفترة من إبريل 2014 إلى يوليو 2014 بهدف تقييم تأثير الحرارة والرطوبة النسبية التي تسود في السترة الشجرية والمساحات المكشوفة على نشاط البحث عن الغذاء بواسطة الارضة من جنس مايكروتيرم (Microtermes). كان الموقع الاول في الضفة الشرقية للنيل الازرق (محلية السوكي- حلة سعيد) بينما جاء الموقع الثاني في الضفة الغربية (محلية أبوحجار – سيرو). تم تنفيذ التجربة بتصميم القطاعات العشوائية الكاملة بأربعة مكررات. تم تكرار التجربة في كل موقع في قطع (Plots) تبعد الواحدة عن الاخرى بمقدار 2 متر. تم وضع 10 طعوم خشبية أفقياً على كل خط بحيث تبتعد الواحدة عن الاخرى بمقدار متر معطياً جملة 400 طعم في كل موقع. تم أخذ القراءات كل أسبوعين وتم حساب عدد الطعوم المصابة كنسبة مئوية من العدد الكلي. أخضعت التجربة للتحليل الإحصائي بواسطة برنامج (SAS). أوضحت الدراسة وجود فرق معنوي بين إصابة الطعوم الخشبية الموضوعة تحت السترة الشجرية (المظلة) في البستان مقارنة مع نسبة الإصابة في الطعوم الخشبية الموضوعة في المساحات المكشوفة في موقعي الدراسة حيث ازداد نشاط الارضة تحت السترة الشجرية عنه في المساحات المكشوفة. أظهرت الدراسة أيضاً أن رحلات جمع الغذاء تنشط مع انخفاض درجة الحرارة وارتفاع الرطـوبة النسبية.

كلمات مفتاحية: الارضة، النشاط الغذائي، متساوية الاجنحة

Introduction

Termites, a common name for numerous species of insects, comprising the order Isoptera, a Latin term referring to the fact that adult termites have two pairs of wings that look very much alike. The infra order name is derived from the Greek words iso (equal) and Petra (winged), which refers to the nearly equal size of the fore- and hind-wings (Bignell et al., 2010).

Termites feed mainly on wood and other materials containing cellulose. This Termite predilection to feeding on wood has always put them in conflict with man. Sudan is a vast country with a total area of about 2.5 million square kilometer. The country is populated by approximately 30.5 million (El shafie, 2001). Eighty percent of the work force is engaged in agriculture and is living in the country side. The Sudan is climatically and geographically very divers, containing deserts, semi-deserts, shrubby and woody savanna lands. The Sudan termite fauna also reflects this topological and climatologically diversity. Some Sudan termites are destructive feeders and can cause damage to agricultural crops and homes. Several published studies provide valuable overview of termites as pests of crops in Sudan (Schumtterer, 1969; Kambal, 1975; Wood and Kambal,1984; Abd El Nour, 1985; El Bakri,1986; Tiben *et al*.,1990).

Both the worker and soldier castes lack wings and therefore never fly, so termites are predominantly reliant upon their legs to move around (Bignell et al., 2010). Workers do not forage unprotected and are rarely found out in the open. They rely on sheeting and runways to protect them from predators (Both the worker and soldier castes lack wings and therefore never fly so termites are predominantly reliant upon their legs to move around (Bignell et al., 2010). Foraging workers use semiochemicals to communicate with each other (Costa-Leonardo *et al*., 2013). In one species, *Nasutitermescostalis*, there are three phases in a foraging expedition: first, soldiers scout an area. When they find a food source, they communicate to other soldiers and a small force of workers starts to emerge. In the second phase, workers appear in large numbers at the site. The third phase is marked by a decrease in the number of soldiers and an increase in the number of workers. The most efficient forager is able to build over non-woody material, to forage over long distances and have efficient defensive castes (Costa-Leonardo *et al*., 2013).

Daily and seasonal factors affect termite activity, distribution and population dynamics. Moisture is the major factor closely linked to temperature that affects termite activity. Changes in environmental conditions cause changes in termite behavior. The special structure of colonies

depends on environmental conditions. Some termites are more tolerant to environmental factors, this can depend on the size or degree of sclerotization of the cuticle as well as on adaptations linked to their normal habitat (Cornelius and Osbrink, 2010). The termite's activity is associated with the temperature. It is high during the spring and summer. However, an increase in temperature, even in the winter months, can cause an increase in activity (Lewis *et al.*, 2011). Activity is also lowest during the morning, and peaking in the late afternoon. As the termites become more active, they have an increase in the release of CO_2 (Shelton, 2001). Turner (2001) mentioned that termites require relative humidity around 70 % to 80 %. However, the nest mean temperature is 26.16°C ± 4.18°C in winter and 31.73°C ± 2.94 in summer. Temperature and relative humidity (RH) play a vital role in influencing foraging behavior of desiccation prone termites (Bignell et al., 2010). No previous studies were undertaken to determine the best combination of temperature and RH for foraging of termite in Sudan.

The objective of the presents study is to assess the influence of temperature and relative humidity which prevail in trees canopy and in open areas on foraging activity of the termite (*Microtermisthoracalis*) in two different locations in Sinnar State.

Materials and Methods

The study area

This study was conducted in two different sites during the period from April 2014 to July 2014 in Sinnar State. The first site was Siro (Abuhujar locality) orchard situated at western bank of the Blue Nile River (Latitude 12.49° North, Longitude 33.59° East and Altitude 429 meters above sea level). The second site was at Hilat Saeed (Suki locality) orchard situated at the eastern bank of the Blue Nile River (Latitude13.15° North, Longitude 33.94° East, and Altitude 436 meters above sea level). The soil of the research site is predominately loamy soil composed of loam, sand and organic matter. The climate of the region is described as tropical savanna where annual rainfalls range from 350 to 450 mm (SMAD, 2015). The mean maximum and minimum monthly temperature range from 40.9° C in April to 33.2°C in July and from 25.4°C in April to 23°C in July, respectively.

Experiment and sampling

An area of 25 m × 25 m was marked out in Abuhujar and in Elsoki. In each site plant leaves, twigs and other organic matters were cleaned to avoid competition with the experimental baits in the

attraction of termites. The area was subsequently divided into four equal size plots each measuring 10 m × 10 m with a 3 m between each two adjacent plots. In each plot 10 parallel rows, 1 m a part was measured, ten wood baits were laid horizontally along each row at 1 m spacing, thus making 100 baits on each of four replicate plots total 400 baits per treatment (under shade and /or open spaces). The ten wooden baits along each row were examined for termite damage at 2-weeks intervals. Attacked baits were replaced by new baits on each monitoring occasion. The number of attacked baits was expressed as percentage of the initial number.

Statistical Analysis

The data collected were subjected to arcsine transformation and analysis was carried out using (SAS/ STAT, 2003) method of analysis. Means were compared according to Duncan's Multiple Range Test (DMRT). Results of analysis were presented as Means.

Results and Discussion

Foraging activity in various termite species is influenced by an array of biotic and abiotic factors. Of the abiotic factors, RH and temperature, play a vital role in affecting foraging behavior that ultimately determines their survival (Potter, 2001). The present study sought to assess the influence of ambient temperature and relative humidity on the foraging activities of termite in Siro and Hillatsaeid- Sinnar State in the Sudan.

Termites foraging activity at Siro site

The lowest mean damage to wood baits placed on the soil surface in trees canopy occurred in 15th May (48.85) (Table 1) where the ambient temperature was 34.4°C and RH of 51% (Figure 1). On the other hand, the highest mean damage was recorded in 15th June (57.99) (Table 1) with temperature at 31.3°C and RH at 58% (Figure 1). This result suggested that the small decrease in ambient temperature accompanied by a moderate rise in relative humidity added advantage for termites activity.

Levels of foraging activity on wood baits placed in the open area are shown in (Table 2), where baits were attacked throughout the exposure period which extended from 15thApril to 15thJuly.The maximum mean damage was recorded in 15thApril (51.96) with temperature at 36.5°C and RH at 34 % (Figure 1). The lowest mean damage occurred in 1stJuly (35.44) with temperature at 29.0°c and RH 78% (Figure1). This result indicated that the combination of low temperature

(29.0°C) and high relative humidity (78%) in July did not enhance foraging and this was not expected and was not in consistent with Potter (2001) who stated that low temperature and high relative humidity influence foraging behavior of termites.

Termites foraging activity at Helat Saeed site

Foraging by termites in the tree canopy at this site (Table 3) followed a fluctuating pattern (up and down) throughout the experimental period. The lowest mean damaged baits occurred in15th April (47.90) with temperature at 40.9°C and RH at 32 % (Figure 2). On the other hand, the highest damage was recorded in 15th May (58.30) with temperature at 39.8°C and RH at 49 % (Figure 2). It is interesting to notice that a decrease in temperature as small as 1% (40.9°C to 39.8°C) was adequate to increase foraging activity of termites resulting in high damage to wood baits.

Foraging activity by termite in open area at the same site followed an increasing pattern during April and early May, then followed by a sudden decline in mid May and continued steadily thereafter up to the end of the experimental period. The lowest mean damage to wood baits (37.10) (Table 4) was found in 1st July with temperature at 33.2°C and RH at 80 % (Figure 2), whereas, the highest damage to wood baits (55.50) (Table 4) was recorded in 1st May with temperature at 39.8°C and RH at 49 % (Figure 2). The results of foraging activity in the open area indicated that some termite species might have a wide range of acceptable temperature and relative humidity levels. Generally the findings of this study suggested that foraging by termites in tree canopies was influenced by temperature and relative humidity. This approves the statement mentioned by Renaud *et al*. (2011) that tree canopy and tree transpiration has moderating effect on meteorological parameters such temperature and relative humidity.

Conclusion

The ecological considerations to know the minimum, maximum and optimum temperature and relative humidity, that enable termites to maximize their foraging activity, was very important in suggestion of termites control strategies. Accordingly, conclusions could be drawn that termites damage increases with the increase of relative humidity, whereas it decreases as temperature increases. However, the termites foraging activity in tree canopy is greater than that in open area.

Table (1): Percentage mean attack on wood baits placed in trees canopy in Abuhujar site (Sairo) during 3 months exposure period (15thApril-15thJuly, 2014)

Rows of wood baits	1	2	3	4	5	6	7	8	9	10	Mean
15th/April	58.28ab (70)	51.34ab (60)	64.18ab (80)	38.67ab (40)	32.90b (30)	41.99ab (45)	73.40a (85)	50.90ab (60)	57.11ab (70)	50.90ab (60)	**55.35**
1st/May	45.00a (50)	47.88a (55)	57.10a (70)	50.89a (60)	35.33b (70)	64.17a (80)	67.50a (85)	45.00a (50)	53.78a (65)	67.50a (85)	**55.59**
15th/May	63.83a (80)	57.10a (70)	42.11bc (45)	47.88abc (55)	36.22c (35)	53.84ab (45)	56.79ab (70)	50.77abc (60)	35.78c (35)	56.79ab (70)	**48.85**
1st/June	57.10ab (70)	67.50a (85)	54.22ab (85)	56.79ab (70)	45.00b (50)	50.89ab (60)	54.22ab (65)	54.22ab (65)	63.44ab (80)	47.88ab (35)	**55.12**
15th June	63.44a (80)	56.79a (70)	50.77a (60)	64.17a (80)	45.00a (50)	63.44a (80)	56.79a (70)	61.16a (75)	60.11a (75)	58.28a (70)	**57.99**
1st/July	64.18ab (80)	50.77ab (60)	54.22ab (65)	53.78ab (65)	54.22ab (65)	48.01ab (55)	48.01ab (55)	47.99b (45)	53.79ab (65)	71.56a (90)	**57.99**
15th/July	54.22a (65)	54.22a (60)	56.79a (70)	57.11a (70)	61.17a (75)	64.18a (80)	50.90a (60)	48.01a (55)	48.01a (55)	61.17a (75)	**54.5**
Mean	**58.01**	**55.09**	**56.10**	**52.76**	**44.26**	**55.22**	**58.23**	**51.15**	**53.15**	**59.16**	

Means with same letter (letters) row wise are not significant at (0.05) probability level according to Duncan's Multiple Range Test (DMRT); data between parentheses are the actual data.

Table (2): Percentage mean attack on wood baits placed in open areas at Abuhujar site (Sairo) during 3 months exposure period (15thApril-15thJuly, 2014)

Rows of wood baits	1	2	3	4	5	6	7	8	9	10	Mean
15th/april	48.33a (70)	61.61a (60)	45.00a (80)	45.00a (40)	57.11a (30)	36.44a (45)	61.17a (85)	52.39a (60)	80.78a (70)	38.67a (60)	**51.96**
1st/may	45.00a (50)	41.68a (45)	45.00a (50)	45.00a (50)	41.68a (45)	41.61a (35)	54.22a (65)	29.89a (25)	38.67a (40)	33.21a (30)	**40.89**
15th/may	51.76ab (65)	50.89ab (60)	47.88ab (55)	45.00ab (50)	57.10ab (70)	50.74ab (60)	60.10a (75)	45.00ab (50)	46.22ab (35)	38.66ab (40)	**48.51**
1st/june	51.33a (60)	33.21a (30)	39.10a (40)	39.33a (40)	32.89a (30)	45.00a (50)	45.00a (50)	45.00a (50)	39.10a (40)	39.23a (40)	**40.91**
15th june	39.00ab (25)	47.88ab (50)	53.78a (65)	29.88b (25)	39.23ab (40)	29.00b (15)	47.88ab (55)	32.82b (20)	47.88ab (55)	41.61ab (45)	**37.90**
1st/july	33.32bc (20)	33.71bc (15)	45.00ab (50)	50.77a (60)	39.10abc (40)	26.50bc (20)	42.11ab (45)	44.11ab (40)	45.00ab (50)	32.32bc (20)	**35.44**
15th/july	50.89a (60)	45.00a (50)	47.88a (55)	29.88a (25)	45.00a (50)	45.00a (25)	29.88a (55)	48.01a (35)	35.78a (50)	45.00a (15)	**39.98**
Mean	**45.66**	**44.85**	**46.23**	**40.69**	**44.58**	**39.18**	**48.62**	**42.46**	**47.63**	**38.38**	

Means with same letter (letters) row wise column are not significant at (0.05) probability level according to Duncan's Multiple Range Test (DMRT); data between parentheses are the actual data.

Table (3): Percentage mean Mean attack on wood baits placed in trees canopy in Elsuki site (Hilatsaeed) during 3 months exposure period (15th April-15th July, 2014)

Rows of wood baits	1	2	3	4	5	6	7	8	9	10	Mean
15th/April	45.00a (50)	45.00a (50)	33.21a (30)	51.34a (60)	51.44a (50)	55.40a (55)	52.39a (60)	41.68a (45)	39.34a (25)	67.50a (85)	**47.90**
1st/May	56.79ab (70)	50.77b (60)	50.22b (65)	46.18ab (80)	60.12ab (75)	61.17ab (75)	42.12b (45)	39..11b (40)	51.34b (60)	80.78a (95)	**56.10**
15th/May	53.78a (65)	51.34a (60)	54.22a (65)	64.18a (80)	64.18a (80)	58.28a (60)	48.01a (55)	55.40a (65)	63.44a (80)	70.39a (80)	**58.30**
1st/June	42.12a (45)	36.22a (35)	50.77a (60)	45.00a (50)	63.44a (80)	53.78a (65)	47.89a (55)	45.00a (50)	52.50a (50)	47.89a (55)	**47.70**
15th June	67.50a (85)	56.79cde (70)	63.44bc (80)	53.78def (65)	47.88f (55)	50.77ef (60)	56.79def (70)	71.56a (90)	60.10bcd (80)	47.88f (55)	**57.70**
1st/July	60.12a (75)	60.17ab (75)	53.78ab (65)	48.01ab (55)	61.17ab (75)	60.12ab (75)	45.00ab (50)	39.11b (40)	42.12b (45)	73.40a (85)	**54.40**
15th/July	61.16a (75)	57.10ab (70)	45.00ab (50)	45.00ab (50)	45.00ab (50)	57.10ab (70)	64.17a (80)	53.79ab (65)	63.44a (80)	36.22b (35)	**52.80**
Mean	**55.22**	**51.05**	**50.09**	**50.49**	**56.17**	**56.66**	**50.91**	**49.37**	**53.18**	**60.58**	

Means with same letter (letters) row wise column are not significant at (0.05) probability level according to Duncan's Multiple Range Test (DMRT); data between parentheses are the actual data.

Table (4): Percentage mean attack on wood baits placed in open area in Elsuki site (Hilatsaeed) during 3 months exposure period (15thApril-15thJuly, 2014)

Rows of wood baits	1	2	3	4	5	6	7	8	9	10	Mean
15th/April	45.00abc (50)	50.77ab (60)	29.89bc (25)	29.89bc (25)	23.50c (15)	35.61abc (35)	35.78abc (35)	47.89abc (55)	61.17a (75)	39.11ab (40)	**39.76**
1st/May	56.79a (70)	63.44a (80)	61.17a (75)	47.89a (55)	57.11a (70)	56.79a (70)	57.11a (70)	60.12a (75)	38.62a (40)	57.11a (70)	**55.50**
15th/May	41.68abc (45)	36.22abc (35)	26.56bc (20)	38.33ab (55)	54.22a (65)	20.44c (10)	50.90ab (60)	45.00abc (50)	36.22abc (35)	48.01ab (55)	**42.40**
1st/June	48.01a (55)	29.84a (25)	29.89a (25)	35.78a (35)	33.21a (30)	41.68a (45)	42.12a (45)	33.21a (30)	50.77a (60)	53.78a (65)	**39.70**
15th June	36.22abc (35)	53.78a (65)	54.22a (65)	38.66abc (40)	45.00abc (50)	26.82bc (20)	47.88ab (55)	25.82c (20)	42.11abc (45)	29.88bc (25)	**39.90**
1st/July	29.88a (25)	42.11a (45)	42.11a (45)	39..23a (35)	41.99a (60)	38.66a (35)	36.22a (35)	31.72a (25)	18.44a (10)	41.99a (45)	**37.10**
15th/July	36.22a (35)	45.00a (50)	41.68a (45)	45.00a (50)	35.78a (35)	33.21a (30)	45.00a (50)	25.83a (20)	50.90a (60)	32.90a (30)	**39..20**
Mean	**41.97**	**45.88**	**40.78**	**44.96**	**40.25**	**36.17**	**40.00**	**38.51**	**42.60**	**42.82**	

Means with same letter (letters) row wise column are not significant at (0.05) probability level according to Duncan's Multiple Range Test (DMRT); data between parentheses are the actual data.

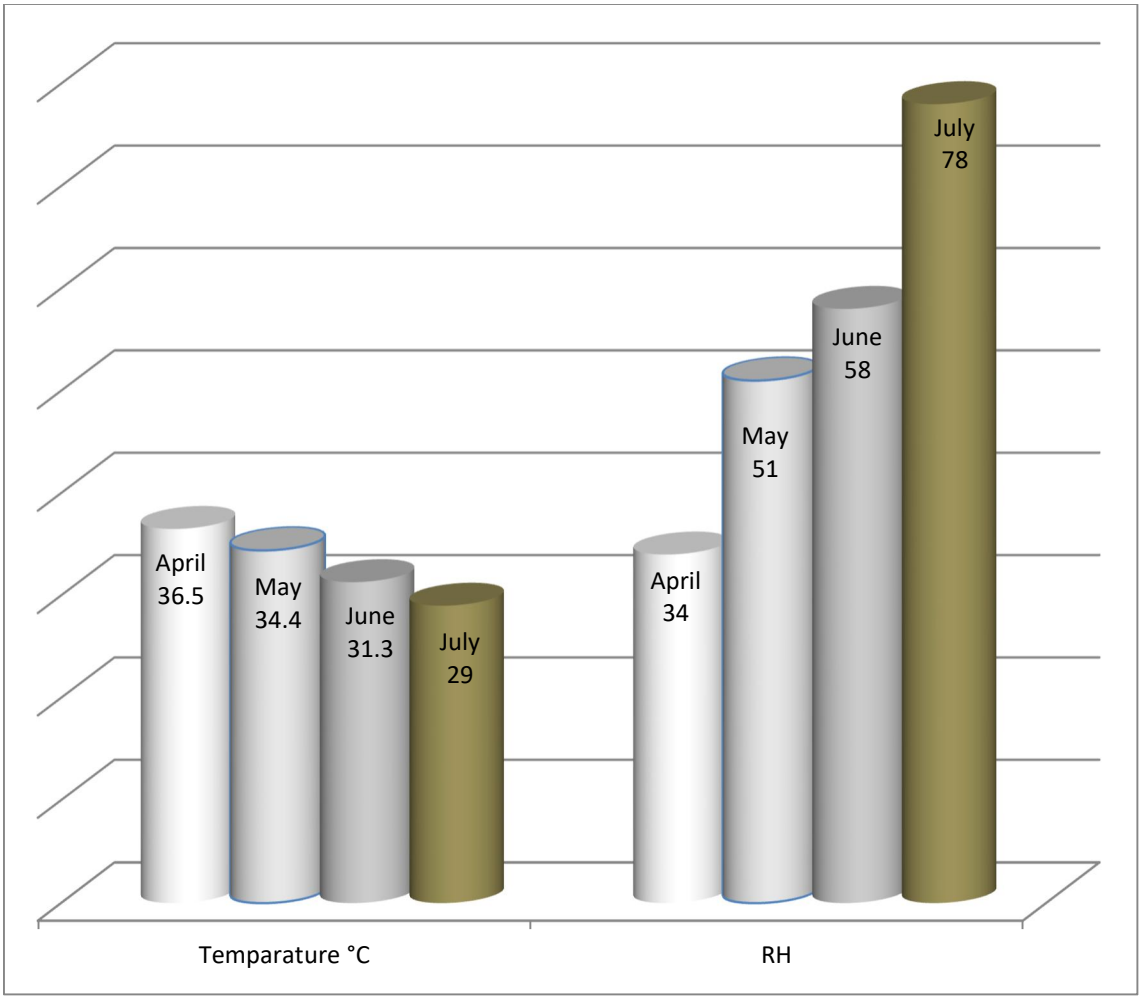

Figure (1): Average monthly temperature and RH for Siro site

Source: Abunaama Metrological Station.

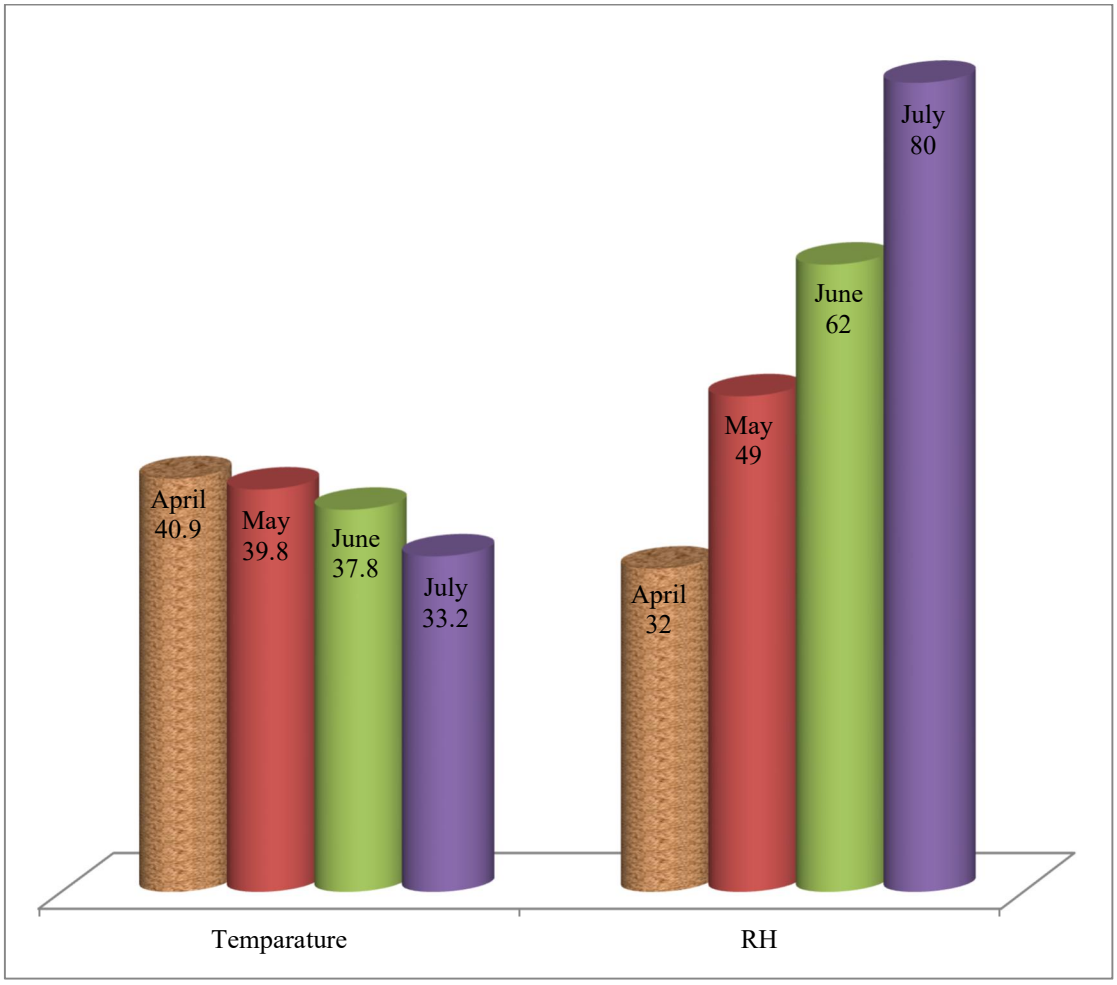

Figure (2): Average monthly temperature and RH for Hillat Saeed site

Source: Aumbenain Metrological Station.

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