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The Effects of Shelterbelts on some Climatic factors in Mechanized Rain-fed Agricultural Schemes in Ghadambaliya Area, Gedarif State-Sudan.

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Abstract

The study was conducted in Gedarif state, Ghdambeliya area during the period (February-March) 2022, to assess the effect of shelterbelts on soil moisture, soil temperature and evaporation, where three shelterbelts were chosen. Average heights of shelterbelts were measured to determine the distance between the belt and the sites from which soil samples were taken; distances were, 5xheight, 10xheight, 15xheight, 20xheight, 25xheight and 30xheight behind the belt, distances in front of the belt were, 2.5xheight, 5xheight and 10xheight; and one soil sample was taken from inside the belt to describe the soil between trees, and one soil sample was taken from unprotected area. The temperature was measured with a thermometer at a depth of 5 and 10 cm, also the evaporation measured by beach tube inside the belt and unprotected area. The data was subjected to analysis of variance and mean separation method using the software statstix-10 and SPSS.The results showed that the soil temperatures inside the shelterbelts were significantly lower compared to the soil temperatures in the unprotected area, also the results indicated that the soil moisture inside the shelterbelts were higher compared to the soil temperatures in the unprotected area. The result showed that the evaporation rate inside the belt was significantly reduced compared to the unprotected area.

Keywords: Shelterbelts, Evaporation, Soil moisture, Soil temperature, Gadambalyia

تأثيرات الأحزمة الشجرية على بعض العوامل المناخية بمشاريع الزراعة الآلية المطرية بمنطقة القدمبلية، ولاية القضارف-السودان

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المستخلص

أجريت هذه الدراسة بولاية القضارف في منطقة القدمبلية خلال الفترة من (فبراير- مارس) 2022 لإبراز أثر الأحزمة الشجرية علي رطوبة التربة، درجة حرارة التربة والتبخر. حيث تم إختيار ثلاثة أحزمة شجريةوتم قياس متوسط إرتفاع الأحزمة وذلك لتحديد المسافة بين الحزام ومواقع أخذ عينات التربة وكانتالمسافات كالآتي: 5× إرتفاع، 10×إرتفاع، 15×إرتفاع، 20×إرتفاع، 25×إرتفاع، 30×إرتفاع الحزام خلف الحزام. المسافات أمام الحزام كانت 5.2×إرتفاع، 5×إرتفاع، 10×إرتفاع الحزام و أخذت عينة من داخل الحزام لوصف التربة بين الأشجاركما اخذت عينة في منطقة غير محمية وتم تكرار هذه التجربة ثلاثة مرات في كل حزام.تم قياس درجة حرارة التربة في الموقع بميزان حرارة علي عمق 5سم و10سم. كما تم قياس التبخر داخل الحزام وفي المنطقة غير المحمية بواسطة انبوبة بيشى (beach). تم تحليل البيانات باستخدام statstix-10 وSPSS. أظهرت النتائج أن درجة حرارة التربة داخل الأحزمة الشجرية كانت أقل بشكل ملحوظ مقارنة بدرجات حرارة التربة في المنطقة غير المحمية ، كما أوضحت النتائج أن رطوبة التربة داخل الاحزمة الشجرية اعلى من رطوبة التربة في المنطقة غير المحمية. ايضاً أظهرت النتائج أن معدل التبخر داخل الحزام قد انخفض بشكل كبير مقارنة بالمنطقة غير المحمية

الكلمات المفتاحية: الأحزمة الشجرية، التبخر، درجة حرارة التربة، رطوبة التربة، القدمبلية

Introduction

The Gedaref state is the first part of the Sudan in which mechanized rain fed farming was introduced. Mechanization first started in Ghadambaliya area north of the Gedaref state then extended south and south west.(Ahmed, 2015). Shelterbelts planting began in Sudan in the forties in many locations, including Nuri in the northern State and Gundato near Shendi, and in the fifties Naishaishiaba belt was planted outside the city of Wad Medani, and in the sixties shelterbelts belts were planted outside the city of Khartoum (Green Belt), (Abdelmagid and Eiman, 2010). The shelterbelts should constitute about 10% of total mechanized farm area. Inclusion of shelterbelts in the mechanized farming system started in 1994. (Elamin and Elmadina, 2014). Shelterbelts are strips of trees, shrubs, and grasses planted in rows raised at right angle to the wind direction, to reduce wind velocity and give general protection to roads, canals, agricultural fields, woody stems, branches and thick foliage help reduce wind hazard (Nair, 1989). Shelterbelts are planted mainly for protection against the damaging effects of winds and wind-blown sands. However they have many benefits such as: Preventing soil erosion, improving the microclimate for growing crops, vegetables and fruits and sheltering people and livestock, they can also serve other functions such as fencing and boundary demarcation. Where wind is a major cause of soil erosion and moisture loss in dry areas, windbreaks can increase and sustain crop productivity. Shelterbelts may also supply wood and non-wood products. (Rocheleau *et al*.,1988). In arid regions, Shelterbelts save the moisture (from rainfall or irrigation) in the soil. Al Motawa (1985) reported that protected soil may have up to 7% more moisture than unprotected ones. He further stated that the reduction of the evapotranspiration in the shelterbelts itself or adjacent plants are usually one of the most evident effects of windbreaks not only during hot periods but alsoin cool wet ones. Reduction of wind velocity reduces evaporation from both open water surfaces and soil surfaces, particularly during seasons of high temperatures and can reduce water loss from irrigation canals and from sprinkler irrigation systems. Evaporation is the loss of water from open bodies, such as lakes, reservoirs, rivers, wetlands and bare soil, but transpiration is the loss from living plant surface. Several factors other than physical characteristics of the water, soil and plant surface are affecting the evaporation process. The more important factors include solar radiation, surface area of open bodies of water, wind speed, density and type of forest plantations, availability of soil moisture, root depth, reflected land surface characteristics and season of year. Rain is considered the main source of irrigation in mechanized rain-fed agricultural schemes in the study area, and the annual amount of rainfall is not constant and mostly insufficient for successful cropping season, and the exposure of this water to evaporation affects crop productivity.(Ahmed, 2015). Also soil moisture and soil temperature affect crop productivity, shelterbelts play a major role in this field.This area was not addressed well by previous studies, likewise in the irrigated schemes. This study can provide some information that helps farmers and decision-makers to make use of how can shelter belts benefit rain fed agriculture. The objectives of this study were to determine the effects of shelterbelts on soil temperature, soil moisture and evaporation, in rain-fed agricultural schemes in Ghadambliya Area.

Material and Methods

Features and specifications of the selectedshelter belts

Gedarif State-Sudan, under consideration, lies southeast of Khartoum. It occupies, the southern part of Kassala state in eastern Sudan. It lies between latitudes 12^o 45' N and 14^o 15' N and longitudes 34^o E and 37^o E (Approximately). The areas under study isabout 45kms from Gedarif. It lies between latitude 14^o N and 14^o -15^o longitudes 35 ^{o} E – 35.30 ^{o} E (Ahmed and Desougi, 2015).Three shelterbelts were selected:The first belt in the northern area, Kilo 6, was 4 kilometers long, 300 meters wide, and the distance between trees was 3 × 3 meters, and the predominant trees were*Acacia seyal*. The average height was 4 meters, and the average trunk diameter was 9cm, and it was planted in 2008. The second belt in the northern area also has a length of 4.5 km and a width of 400 meters. The distance between trees was 3× 3 meters. The average height was 4 meters and the average trunk diameter was 9 cm, and the predominant trees are *Acacia seyal*, and it was planted 2008. The third belt is located in the central area. It is called Abu Jinnah belt. It was 3 km long and 200 meterswidth. The distance between trees was 5× 5 meters, the predominant trees were*Acacia seyal.*The average height is 3meter and the average trunk diameter was 7cm, and It wasplanted in 1998 Fig (1,2 and 3).

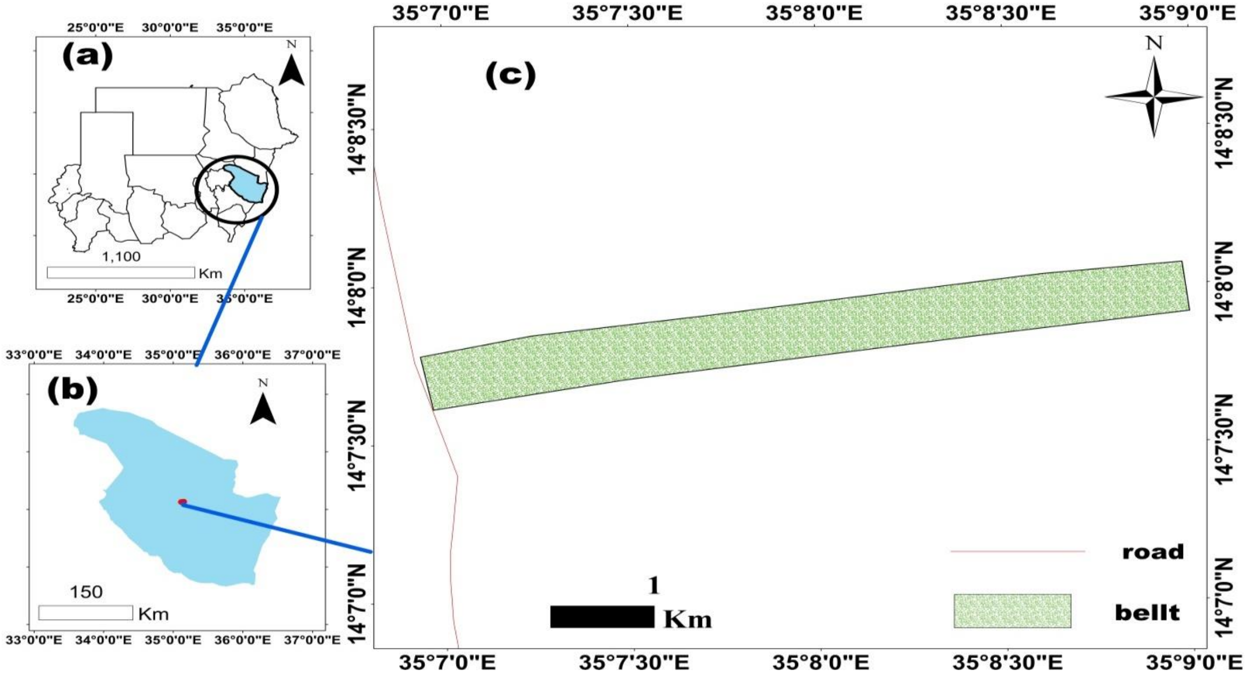

Figure: (1) Kilo 6 (A) shelterbelt

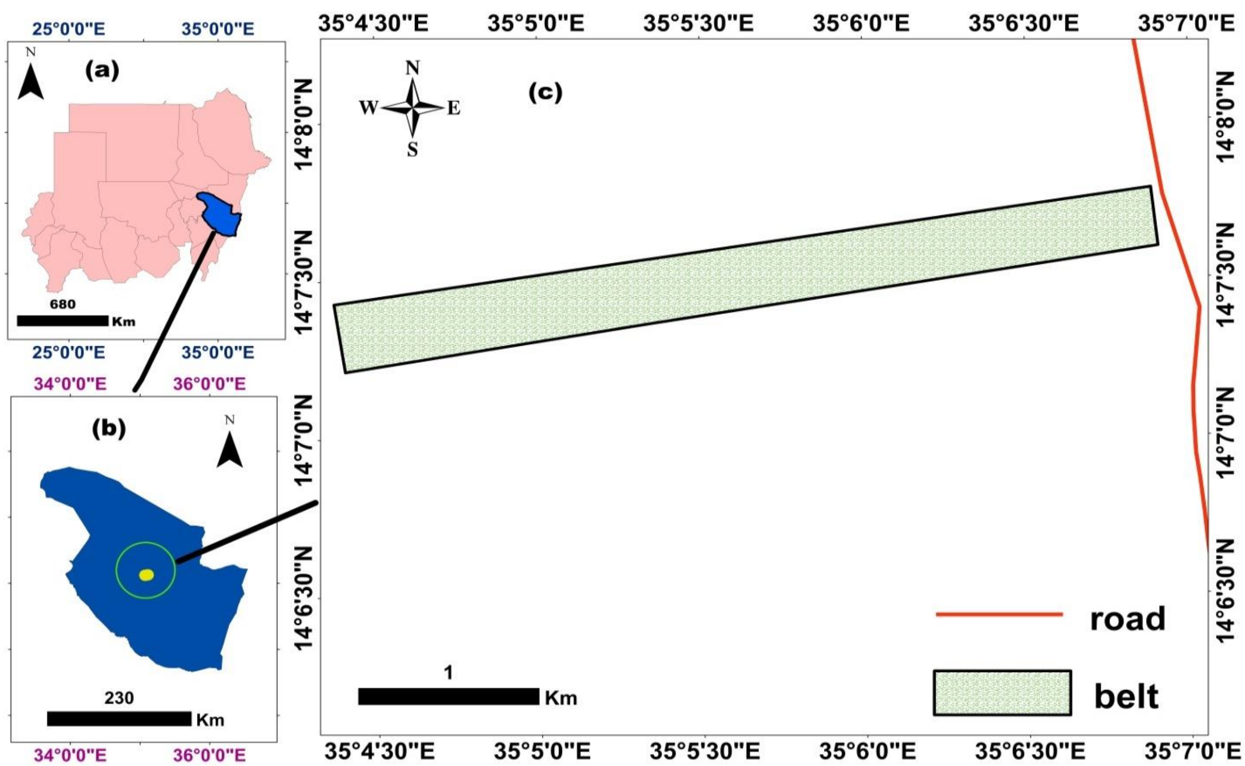

Figure: (2) Kilo 6 (B) shelterbelt

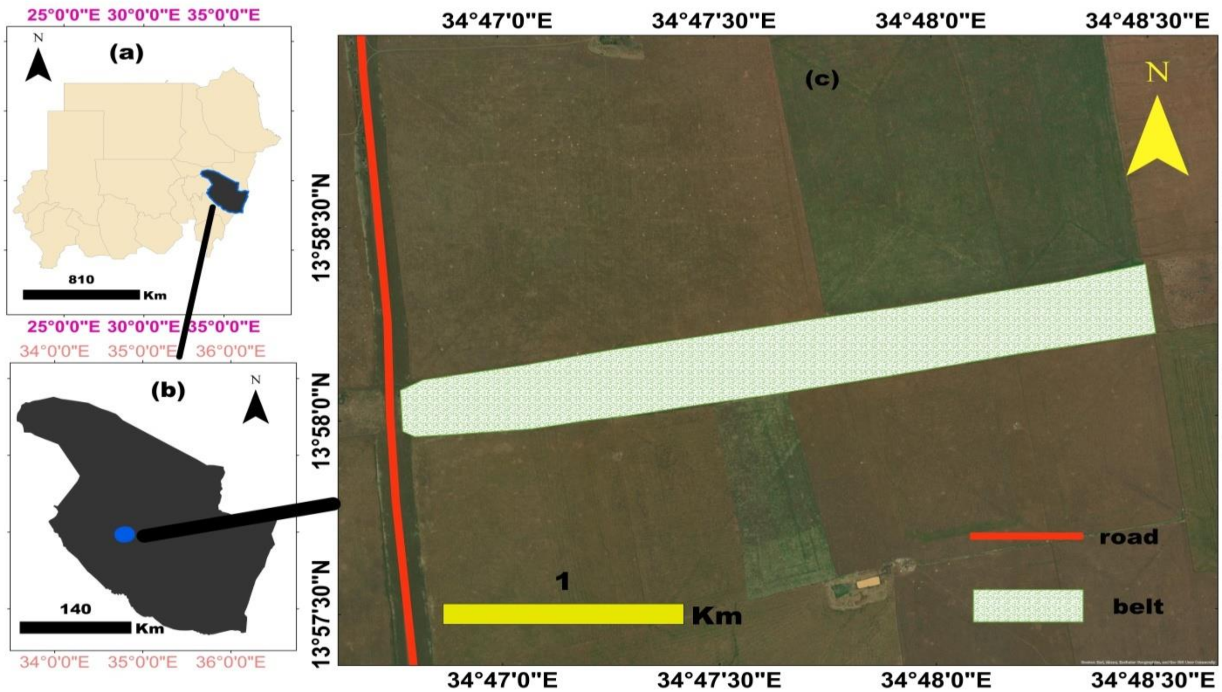

Figure: (3) Abu Jinnah shelterbelt

Experimental design

Three lines were chosen in each of the three selected shelter belt. In each line, ten points were identified at different distances according to height of the shelterbelt 2.5H, 5H and 10H on the windward side;5H, 10H, 15H, 20H, 25H and 30H on the leeward side, and one pit was dug in the middle of the belt to describe soil characters. Also three samples were selected in each shelterbelt located outside the protected area. Suunto Clinometer was used for total tree height measurement as recommended by Mohammed *et al.*, (2022). Soil temperature were measured at depth of 5and 10 cm and soil moisture in each sample (33 samples) in each belt, (99 samples) in the three shelter belts were considered for measurements. Soil samples were taken by the Auger device and collected in plastic bags and transferred to the laboratory of the Mechanized Agriculture Authority in Gedarif state to determinatesoil moisture using Moisture Analyzer (KERN DBS, 60-3) as recommended by (Rasheed *et al*., 2022).The soil temperature was measured using the soil thermometer in the field.Piche tubes at height 2m were used to estimate the amount of evaporation inside the shelterbelt and unprotected area. Evaporation was measured twice a day, six in the morning and six in the evening for five days.The data was subjected to analysis of variance and mean separation method using the software statstix-10 and SPSS.

Results and discussion

Table (1). Mean soil moisture and soil temperature as detected in different shelter belts sites

Shelterbelts	Mean soil temperature 5 cm	Mean soil temperature 10 cm	Mean soil moisture
Kilo 6A	35.727 A	32.879 B	9.3094A
Kilo 6B	34.091 B	32.333 B	9.3012 A

Abugenah	35.879 A	34.242 A	8.4670 B
P	0.008**	0.013**	0.011**

Note: Means carrying the same letters are not significantly different
P= probability, p> 0.05= not significant, P≤ 0.05, 0.04, 0.03, 0.02= *, P≤ 0.01, 0.001, 0.000 = **

Table (1) showed that the highest soil temperature for both depths 5 and 10 cm was recorded in the Abu Jinnah Shelterbelts compared to Kilo 6A and Kilo 6B belts which was recorded the lowest soil temperatures, and this is attributed to the narrow and short height of the Abu Jinnah belt compared to the rest of the Shelterbelts. Also the study reported that the lowers moisture content was recorded in the Abu Jinnah Shelterbelts compared to Kilo 6A and Kilo 6B shelter belts. The result coincided with that reported by(Fengmin Luo *et al*., 2021) Who stated that under the influence of a large-scale shelterbelts, air temperature, land ground temperature and evaporation respectively decreased 5.13% ~ 24.74%, 2.38% ~ 20.09% and 7.06% ~ 17.68%.

Table (2) Effect of distance from the shelterbelts on soil moisture and soil temperature

Area	**Distance from the belt (m)**	**Mean soil temperature 5cm(c°)**	**Mean soil temperature 10cm(c°)**	**Mean Soil moistures (%)**
Protected area	Windward 10H	38.778 A	35.889 A	8.930 AB
	Windward 5H	37.444 AB	34.556 ABC	8.3156 B
	Windward 2.5H	38.889 A	34.889 AB	8.8889 AB
	Leeward 5H	33.889 CD	32.333 CD	8.6878 AB
	Leeward 10H	33.333 D	32.222 CD	9.0144 AB
	Leeward 15H	32.889 D	32.778 BCD	9.6833 A
	Leeward 20H	33.111 D	32.778 BCD	9.2900 AB
	Leeward 25H	32.556 D	31.333 D	9.4278 AB
	Leeward 30H	32.222 D	30.444 D	9.5600 A
Inside the shelterbelts	Inside Belt	35.778 BC	31.556 D	9.1400 AB
Un protected	Un protected	38.667 A	35.889 A	8.3467 B
	P	0.000 **	0.000 **	0.342 n.s
	Grand mean	35.23	33.15	9.02
	C.V %	7.16	7.9	14.11

Means carrying the same letters are not significantly different
C.V = coefficient of variation, n.s = not significant

Table (2) showed that the soil temperature behind the Shelterbelts (Leeward) and inside the shelterbelts were significantly lower compared to the soil temperatures in front of the shelterbelts (Windward) and the unprotected area, this indicates the clear effect of the Shelterbelts on lowering the soil temperature. There is also a similarity between the temperature of the belt area and behind the shelterbelts at windward 5H.On the other hand, there were no significance differences between the inside belt and windward 2.5H, 5H and 10H.These results are in agreement with the findings of Osman (2010) andFengmin Luo *et al*.(2021) who reported that Soil temperature is reduced behind shelterbelts compared with unprotected ground. Also, the results showed that there were no significant differences between the different distances2.5H, 5H and 10H behind the shelterbelts. Also, there were no significant differences between the different distances behind the shelterbelts (Leeward)5H, 10H, 15H, 20H, 25H, and 30H at both depths. Whereas, at a depth of 10 cm, the results showed that the soil temperature of the Behind the belt (leeward side) and the Inside the shelterbelts area decreased significantly compared to the unprotected area and the In front of the Shelterbelts area(Table2). And the results also showed that the temperature at a depth (5) is higher than the temperature at a depth (10). Also the results indicated that the soil moisture inside the shelterbelts was higher compared to the soil temperatures in the unprotected area. These results are in agreement with the findings of Osman (2010).

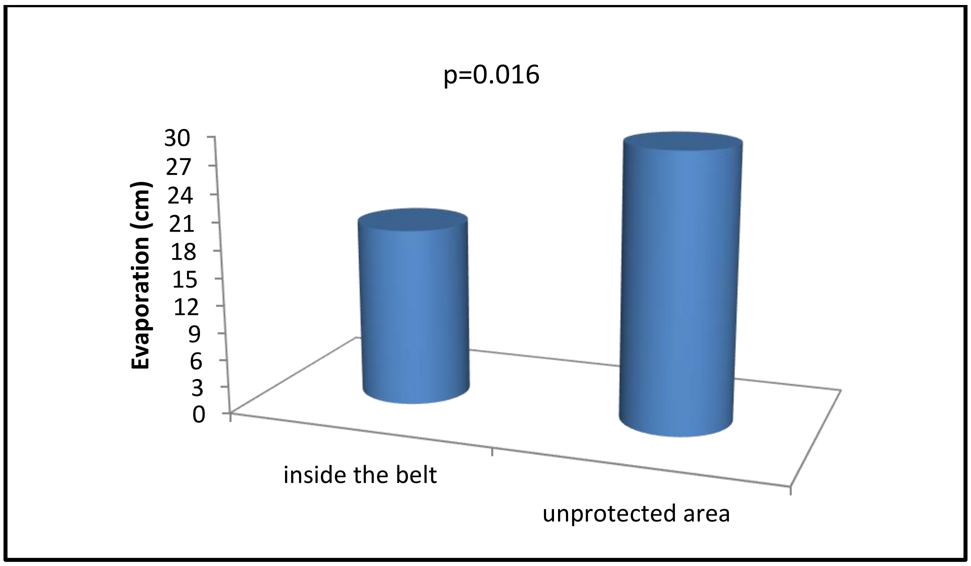

Figure (4) Evaporation inside the shelterbelt and unprotected area

*= significant different

Figure (4) showed that the evaporation rate inside the shelterbelt was significantly reduced compared to the unprotected area. Similar results were observed by (Fengmin Luo *et al*., 2021) who found that the evaporation showed a downward trend inside shelterbelt. Generally the reduction of wind velocity reduces evaporation from both open water surfaces and soil surfaces, particularly during seasons of high temperatures and reduce water loss from irrigation canals and from sprinkler irrigation systems (Dongsheng *et al.*, 1999).

The stability of the microclimate was maintained and natural disasters were reduced by shelterbelts (Zhang *et al*., 2011). Our results showed that under the influence of a large-scale shelterbelts, air temperature, ground temperature and evaporation decreased significantly. The microclimate of shelterbelts was conducive to the overwintering of plants and kept them from the damage of high temperature in summer. Therefore, it played a vital role in plant growth, nutrient accumulation and quality improvement (Fang *et al*., 2020). The relative humidity was found to be increased in some studies by 0.5% ~ 18.6%, whereas the evaporation was also decreased 18.4 ~ 12.828 mm by shelterbelts in the northeastern edge of Ulan Buh Desert. This played a positive role in increasing soil moisture and inhibiting crop transpiration, thereby increasing crop yields and improving the soil quality in long time (Fang *et al*., 2020)

Saturated water vapor was formed when the temperature inside shelterbelt was lower than that outside shelterbelt. The canopy blocked the exchange of airflow between inside and outside shelterbelt. In addition, the water vapor diffusion from inside to outside shelterbelt was reduced by the decrease of wind speed, which resulted in a higher relative humidity inside than outside shelterbelt(Yang,1993).

Conclusion

1-Microclimate was improved by shelterbelts in Ghadambaliya area, including soil moisture, Soil temperature and evaporation inside shelterbelt.

2- Influence of large-scale shelterbelts was better than narrow-band shelterbelts in terms of their impact on soil temperature and soil moisture.

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