Temperature and Evaporation Control by Date-Palm Shading

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Résumé

Deux tests expérimentaux en vue d'évaluer l'effet d'écran de roseaux de palmier-dattier contre les radiations solaires sur la croissance du Komatsuna (*Brassica campestris*) ont été conduits dans un tunnel à vent muni de lysimètre à balance. L'écran de roseaux a permis un bon contrôle de la hausse des températures et le maintien de l'humidité dans la journée. L'étude au champ menée aux Emirats Arabes Unies a cependant montré une hausse de la température sous l'écran des roseaux. Malgré une augmentation du taux de germination, le poids de biomasse fraîche de Komatsuna était réduit suite à l'effet d'ombrage des roseaux qui limite le rayonnement solaire. Ces résultats montrent que les résidus de palmier-dattier pourraient servir d'écran durant le premier stade de croissance c'est-à-dire du semis à la germination.

Introduction

Techniques of water saving cultivation are important ways to expand the cultivated land in the arid regions. However, it is not easy to apply those techniques practically if the system is complex or expensive. On 27 Feb.2004, the Gulf News announced that the depletion of ground water resources grow into a serious problem on United Arab Emirates (UAE) because of the increase in agricultural consumption and recent dry weather conditions (IRC, 2004). As for, the Municipality of Agriculture and Fisheries in UAE already have a vision to develop water saving techniques. Using the residual of date-palm materials could be a good option for their vision.

The objectives of this study were to evaluate the effect of date-palm mulch and roof on the: a) soil water, b) soil temperature, and c) growth of Komatsuna (*Brassica Campestris*). Residuals of Date-palm leaves and stems were available in Gulf Arabic regions, and easy to obtain. Moreover, activate use of local materials is considered one of the effective way of developing agricultural techniques with low cost.

Materials and methods

Performance test using the wind tunnel facility

Laboratory experiment was conducted at the wind tunnel of the National Institute for Earth science and Disaster prevention (NIED), Tsukuba, Japan. Inside of the wind tunnel, air was conditioned to 25°C temperature and 50% of humidity. Short-wave radiation was added regularly every 12 hrs as a sine curve controlled by halogen lamps placed at the ceiling until maximum net radiation was about 500 W/m^2. Four kinds of pots were made from air-dried sand (Toyoura sand and Al Ain sand) and different thickness of organic mulch layer, (dried orchard grass for Toyoura sand "Sand" and roughly fractured date-palm leaves & stems for Al Ain Sand "A_Sand"). Based on the thickness of mulch the four pots treatments were 0 mm (Sand_0mm), 30 mm (Sand_30mm), 50 mm (Sand_50mm) in addition to A_sand with 30 mm thickness of Date-palm mulch to compare the evaporation (Fig. 1). Those four kinds of pots with 0.02 m^2 were exposed to the conditioned air in the wind tunnel. The weights of the pots were automatically recorded by electric balance. The sand surface was sprayed by water (5 mm), then the organic mulch was put on the wet surface and the experimental pots

were kept in the wind tunnel. Two thermocouples (Copper-Constantan) were installed at the sand surface under the mulch layer and at 20 mm depth under the sand surface (Fig.1).

Field cultivation experiment

The experimental field was classifies as sandy soil and located at Al Ain, UAE (24°5' N, 55°6' E). 15 seeds of Komatsuna (*Brassica Campestris*) cultivars were cultivated on October 18 in each line with 4 lines in each plot (1m x 1m). Plant sampled almost every week starting after 10 days from seeding and the final sampling was at Nov.14, 2003. During that period, the average temperature was 29.1°C and relative humidity was 56.1 %. Eight different plots were tested and consisted as follows;

1) S+Ug+Bottom
2) S+Sr+Bottom
3) D+Ug+Bottom
4) D+Sr+Bottom
5) N+Ug+Bottom
6) N+Sr+Bottom
7) N+Ug+non-Bottom
8) N+Sr+non-Bottom

where Ug was the irrigation from irrigation tube in the soil, Sr was the sprinkle irrigation from surface. S was about 40% of shading ratio by un-woven fabric (white), D was about 90 % of shading ratio by Date-palm leaf and stem and N was the non-shade condition. Bottom means that the sand separated by waterproof sheet placed at 0.15 m depth (Fig. 2).

Soil surface temperature (T_s) and leaf temperature (T_{leaf}) of Komatsuna were measured at 21 Days after seeding (DAS) and 22DAS almost every 2hours from 6:00 to 18:00 by infrared thermometer (IT-550,Horiba). Germination Rate (GR) was counted until 10DAS, Survival rate (SR) was obtained from the difference between number of final sampling and 10DAS's counting result. Fresh weight (FW) was measured within 30 min after sampling while the Dry weight was recorded after oven dried for more than 24 hrs.

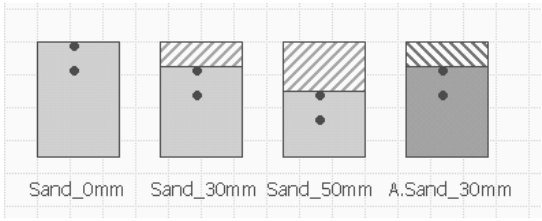

Fig. 1, Pot treatments (soil was packed into the pot, then the mulch layer was set upon the surface. Circles were the position of thermocouple).

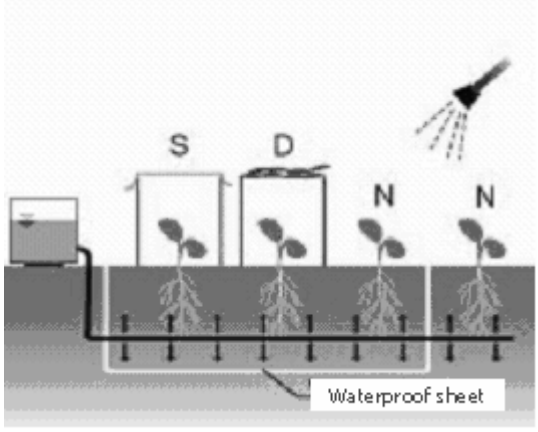

Fig. 2, Combination of the treatments, (Each plot was made by three different factors, Irrigation different, Shading different and presence of water proof sheet).

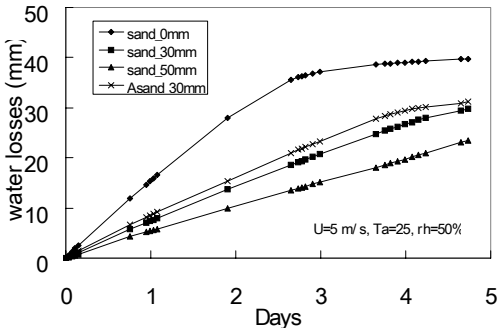

Fig. 3, Water losses by evaporation from sand pot.

Results and discussion

Water losses from wet sand

The result of water losses as cumulative evaporation revealed that 0 mm sand was the highest compared to the other treatments, until the dry layer (DL) was developed, then increased slowly (Fig.3). During the first stage of evaporation, sand surface under the mulch should be wet, because its evaporation rate from the pot was depending on the DL thickness of mulch (Hillel, 1982). A linear relationship was found between the DL thickness and evaporation rate, when the DL thickness increased the evaporation rate decreased (Fig.4).

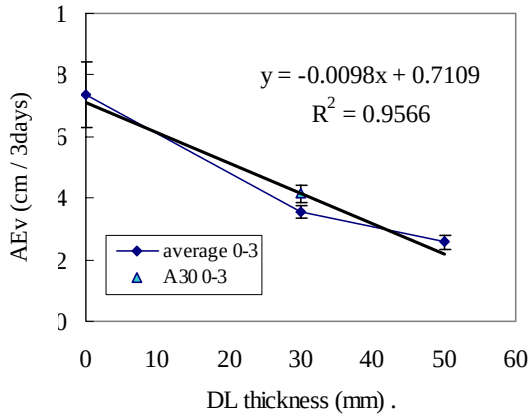

Fig. 4, Averaged evaporation rate 'AEv' (calculated from 0 to 3 days reffered from Figure 3).

Soil temperature difference

There was no change in soil temperature between the treatment as the first day of the experiment inside the wind tunnel and almost less than 25ºC because of the latent heat, however large differences between treatments were found after the first day because of the decrease in soil water content (SWC, Fig.5). Due to the decrease of SWC, the change in soil temperature increased rapidly in non-mulch treatment (sand_0mm) compared to mulch treatment at both depths (0 and 20 mm). The mulch layer interrupted the short wave radiation consequently, the surface soil temperature hardly increased. Moreover the SWC of the surface under mulch layer was gradually decreased.

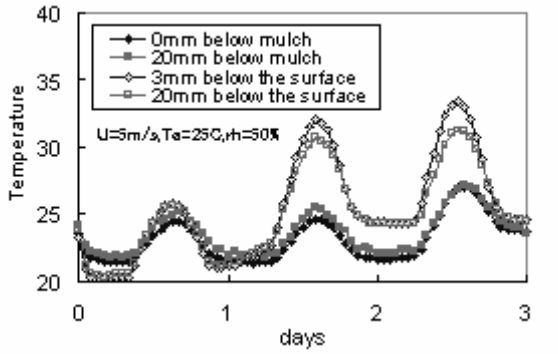

Fig.5, Changes in soil temperature under the wind tunnel conditions.

The results of the field experiment in UAE were presented in Table 1. The result indicated that bottom treatment was better than non-bottom treatment because the GR, SR, FW and DW for the bottom treatment were higher than in non-bottom treatment, while its T_s and T_{leaf} were lower than non-bottom treatment. The GR and SR were the highest in D treatment followed by S and N treatments, respectively, however, the damage caused by the insect was considered. The highest FW and DW were

Table 1 Effect of shade and bottom, GR,SR,FW,DW,T_s and T_{leaf}.

Treatment	Reps	GR*	SR*	FW**	DW**	T_s***	T_{leaf}****
Bottom	12	0.90(±0.08)	0.92(±0.17)	62(±30)	3.2(±1.3)	25.2(±0.9)	26.7(±1.4)
Non-Bottom	4	0.36(±0.25)	0.25(±0.25)	14(±3)	0.7(±0.3)	30.1(±1.1)	32.5(±4.3)
D shade/mulch	4	0.92(±0.06)	0.98(±0.02)	48(±17)	2.5(±0.4)	24.2(±0.5)	27.2(±1.6)
S shade/mulch	4	0.89(±0.09)	0.97(±0.07)	69(±25)	4.1(±1.5)	25.5(±0.5)	27.4(±1.5)
Non shade	4	0.89(±0.09)	0.82(±0.28)	69(±46)	3.0(±1.5)	25.7(±0.8)	31.1(±4.4)

*GR:Germination Rate, SR:Survival Rate,
**FW and DW are the value per unit plant.
***Surface temperature T_s is as a daily mean temperature
****Leaf temperature T_{leaf} was measured at the interval of 3 hrs of 21DAS and 22DAS

obtained from S treatment while the least obtained from D treatment. The highest T_s and T_{leaf} were measured in N treatment while the T_s and T_{leaf} in D and S treatment were almost same.

Germination rate, fresh weight and dry matter

Bottom treatment was better than non-bottom treatment because of the higher SWC. The water proof sheet in the bottom treatment, prevent the loss of soil water by percolation. Due to shading/mulching, the soil temperature was low in D and S treatment; therefore the SWC was high resulted in higher GR and SR compared to N treatment (Fig.6). The higher shading ratio of D (90%) treatment hampered the growth of komatsuna and resulted in low FW and DW compared to S and N (Fig.7). Moreover the result proofed that the date-palm shading is a promising material could be used to promote the temperature reduction, however in which growth stage the material should be added need more investigation.

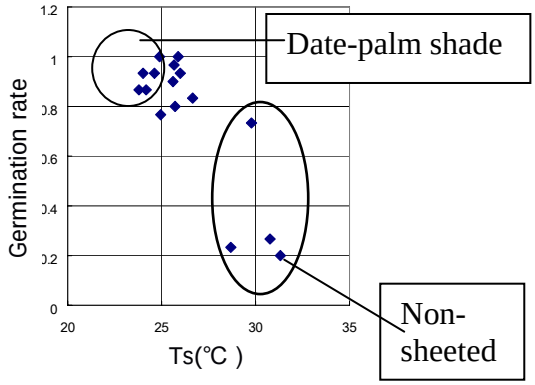

Fig.6 Relationship between Germination rate and soil surface temperature (T_s).

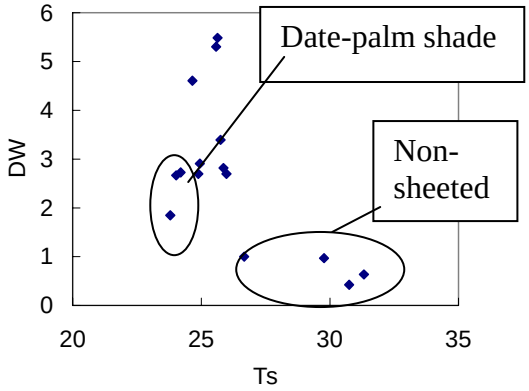

Fig. 7 Relationship between Dry matter weight(DW) and soil surface temperature (T_s).

Conclusions

Results of this study suggest that:

Date-palm materials could control soil temperature-rise and maintain soil moisture in the daytime according to the results of performance test in the wind tunnel and the field experiment in UAE.

The germination rate increased. Although the fresh weight reduced in the field using date-palm shade. The shortage of sunshine by too much shading was the reason of fresh weight reduction.

Date-palm materials, as a shading material, may use in the early stage of growth, from seeding to germination.

Acknowledgement

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