Seasonal Fluctuations of Soil Moisture Content and Condensation Process in Khuzestan Sand Dune

Hassan Rouhipour
Research Institute of Forests and Rangelands, PO Box 13185-116, Tehran, Iran.
Email: rouhi@rifr-ac.ir

Résumé
Dans cette étude trois types différents de Khuzestan (l'ouest du sud d'Iran) découvre la dune a été étudiée dans les termes d'équilibre d'eau et de variation saisonnière de contenu d'humidité de sable. L'humidité de sable et la température ont été mesurés dans les emplacements différents sur les profils de dune pour une période d'une année avec deux intervalle de semaines. Pour plusieurs plantes natales, le point flanchant permanent a été déterminé et comparé au contenu d'eau de sable minimum dans la saison sèche pendant les conditions dures. Il a été trouvé que la plupart de dunes de Khuzestan sont composées de 95 pourcent des particules de fine-sable et fractions de d'argile ou limon a contribué seulement à peu près 5 pourcent à la texture totale. Basé sur les caractéristiques de sable-humidité courbe de le et les variations saisonnières d'humidité, la hauteur critique des dunes de Khuzestan a été estimée à peu près 9 m de la donnée (la terre arable environnante). De plus, il a été trouvé que le contenu d'humidité pour les échantillons de sable pris a montré la nuit un augmenter de 1,5 pourcent dans compare au jour essaie. La raison pour cette différence dans le contenu d'eau peut être relatée au procédé de condensation qui a lieu d'habitude dans la dune en raison de la pente de température entre la surface de sol et a mouillé la couche du sable au dessous.

Abstract
Little work has been published on the water relations of the desert sand dune. On arid zone, dune systems with only 150mm rainfall are immensely rich in plant species in contrast with heavy texture soil under the same ecological conditions. Indeed in comparison with heavy or clay-soil texture, small amount of water in sand texture can have a considerable effect on plant growth and its establishment. In arid zone where evaporation considerably exceeds the amount of rainfall, detailed study of water balance can be very important. In this research program three different type of Khuzestan (south west of Iran) bare dune were studied in terms of water balance and seasonal fluctuation of sand moisture content. Sand moisture and temperature were measured in different locations on dune profile for a period of one year with two week interval. For several indigenous plants, the permanent wilting point were determined and compared with the minimum sand water content along the dune profile in the season with harsh conditions. It was found that most Khuzestan dune systems are composed of 95 percent of fine-sand particles and clay/ silt fraction contributed about 5 percent to the total texture. Water holding capacity was about 5-6 percent by weight and wilting point was around 0.75-1.5 percent for some native shrubs investigated. Based on sand-moisture characteristics curve and seasonal fluctuations the critical height of the Khuzestan dunes was calculated about 10 m from datum (surrounding arable land). Furthermore, it was found that moisture content for sand samples taken at night has shown an increasing of 1.5 percent in compare with day sampling. The reason for this difference in water content can be related to condensation process which usually takes place in sand dune due to temperature gradient between the soil surface and wetted layer of the sand below. The average moisture content, which comes from this phenomenon, was more than 1.5 percent (by volume) which is sufficient for the surviving of the dune plants in rainless period with harsh conditions. This study indicate that there is a potential for the sand filter to be incorporated with

heavy soil texture in order to store more moisture and prevent excess evaporation where desert revegtation is required

Introduction

Pioneer studies by Bagnold(1941) has shown that sand moves by creep and saltation, a process whereby the first sand particles moved by a sufficiently strong wind fall under gravity on the loose dune surface and bounce back into the wind at the same time setting other grains in motion by their impact. Sands movement associate with dry condition make the bare dunes unstable and difficult to established adapted plants particularly in high dune.

Despite the fact that bare dune is unstable, in arid zones, dune systems with only 150 mm rainfall are immensely rich in plant species in contrast with clay soils under the same ecological conditions. This great difference causes to pay more attention about study on sand properties, particularly sand-water relations in dune systems

In arid zones where evaporation considerably exceeds the amount of rainfall (8-10 times or more) detailed study of water balance can be very important. Because in compare with heavy soil texture, small amount of water on sand dune has considerable effect on plants growth and their establishment due to very low suction(Rouhipour, 1985). Salisbury (1952) demonstrated that the average water increment from dew was 0.9 ml per 100 ml soil per night in cloudless conditions, and transpiration measurements showed that this was sufficient to maintain plants exploiting that soil volume in rainless periods. He believed that two processes are responsible for the transportation of water vapor into the different layers of sand. One process takes humidity from the atmosphere into the upper horizons of sand and the other process takes water vapor from the warm and wetter layers underneath. Such a migration of moisture in fact occurs due to diurnal/nocturnal fluctuations in temperature of a sand profile. A number of investigators believe that most of the condensed moisture provided at night returns to the atmosphere during day time Thus its significance in plant nutrition is doubtful. Petrov (cited by Kulic, 1972) considered the dynamic of water vapor of the daily cycle at the surface horizons of sands and determined that the condensed moisture provided at night should primarily return to the atmosphere. But Salisbury (1952) believed that warm moisture laden air from above adjacent sea after sunny days was drawn into the pore space of the sand, as a concomitant of the upward convection-currents maintained especially on the southern face and crest of the dune after dusk, where it was deposited on cold grains as internal dew The aim of this study was: firstly to determine the maximum height of sand dune at which plant can grow and survive during harsh condition in dry season without rainfall. Secondly to find the role of condensation process and its significance to plant growth and finally to seek the suitable and practical method of sand dune stabilization for high dune system based on seasonal fluctuation of moisture.

Methods and materials

Three different types of Khuzestan bare dune in terms of height were selected for this experiment, namely representative of short, medium and high dunes. Sand moisture and temperature were measured in different locations of dune formation, namely windward, crest and leeward on dune profile for a period of one year with two weeks interval using field experiments and laboratory methods In each profile 5 samples were taken from sand surface down to one meter depth and moisture content was measured using gravimetric method. Sand particles movement due to wind velocity in several positions at windward, crest and leeward of the selected dunes were measured using graduated pickets fixed on top of dune. Sand depletion on windward slopes and accumulation on leeward slopes were also recorded weekly. Size distribution of sand particles and capillary rise were measured using dry sieving capillary-sand tube respectively.

Sand moisture-characteristic curve, field moisture capacity and permanent wilting point of the dune materials for numerous native shrubs were subsequently determined Finally water budget and critical height of dune were estimated using water balance equation, sand-moisture characteristic curve and other supplementary studies

Results and discussion

Size distribution particles of the most Khuzestan dunes systems indicated that most sand dune are composed of 95 percent fine grain sand and clay/silt fraction only contributed around 5 percent to the total In this fine sand, field moisture capacity was about 6 percent (by weight) and permanent wilting. point for numerous native shrubs was around 0.75-l.5 percent (by weight Capillary rise for mixed samples was 37 cm. It was found that average water content which comes from condensation was about 1 percent by weight per night in cloudless conditions which was sufficient in my opinion for the survival of dune plants in rainless period (table 1).

Furthermore, based on seasonal fluctuation of sand moisture and permanent wilting point, the critical height of Khuzestan dune was estimated around 10 meters from datum (surrounding flat arable land).The critical height for sand dune is defined as the maximum height at which most native and adopted plants could able to grow and survive during dry seasons with the aid of palisade windbreak or any other chemical stabilizer that fix the movement of sand particles.

Sand moisture characteristics curve was drawn at high and low pressure using pressure plate and Hain's apparatus respectively (Fig.1). As this figure shows three distinct slops were identified on the sand moisture characteristics curve. In the first steep slope of the curve, small amount of water (1.63 to 9.5 percent by volume) is held between wider ranges of water suction (Pf 2 to 4). The second part in which curve is horizontal, a wide range of moisture content (10 to 30 percent) could hold or release at very short range of suctions between Pf 1.5 to Pf 1.75. The third part of curve which represents the saturation state and capillary fringe of the sand, only few percent of moisture hold between Pf 0 to 1.5.

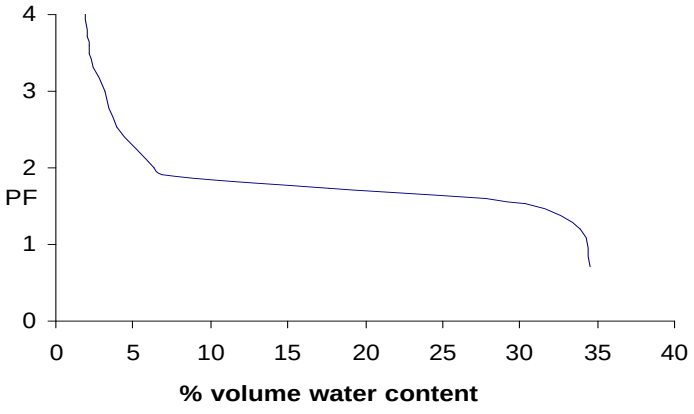

Fig.1 Khuzestan sand moisture characteristics curve (From Rouhipour, 1985)

Table 1. Water content (by weight) in Khuzestan- sand dune before and after dew formation in different slopes of a dune system. (sampling date: 8th Oct. 1985).

Dune direction	Sample depth (cm)	Night samples (%)	Day samples (%)	Night-day gain (%)
windward	0.0-20	0.40	0.31	+0.09
	20-40	2.06	1.64	+0.42
	40-60	2.90	1.08	+1.10
	60-80	3.85	2.10	+1.75
	80-100	2.95	2.15	+0.80
Dune crest	0.0-20	0.49	0.37	+0.12
	20-40	0.98	0.53	+0.45
	40-60	1.54	1.00	+0.54
	60-80	3.22	2.17	+1.05
	80-100	2.93	2.40	+0.53
Leeward	0.0-20	0.36	0.30	+0.06
	20-40	0.69	0.57	+0.14
	40-60	1.04	1.00	+0.04
	60-80	1.86	1.80	+0.06
	80-100	1.95	1.82	+0.13

Conclusion

The primary source of water for dune plants comes from rainfall, and in particular that proportion of it held as moisture-holding capacity of the sand But as Salisbury's studies have shown there must be some other source of water to carry plants through long periods of dry weather It must be remembered that the diurnal and nocturnal temperature variations are considerable on an open sand formation Such fluctuations in sand temperature are sufficient to cause periodical condensation of water vapor in the soil As Table1 shows water content for sand samples taken at night has shown an increasing of 1.65 percent (by volume) in comparison with day sampling The reason for this difference in water content can be related to condensation processes which usually take place in sand dune and consequently has very important effect on water supply for plants growth to survive under harsh condition, the conclusion found by other investigators. the Olsson-Seffer (1909) showed that the capillary rise of water from a free water surface even in very fine sand 30-50 microns particle

size was not more than about 40 cm. The water table in a dune only 3 or 4 m height can therefore make no direct contribution to the moisture requirements of plant rooting to depth only l m. In really high dunes the water table lies many meters below the surface and has no significant effect on plant growth at the dune surface

Literature cited

Bagno1d, R.A. (1941). The physics of blown sand and desert dunes, London; Methuen.

Kulic, N.F. (1979 Water budget and moisture balance of various landscape types of sands in arid zone International Research Courses on Fixation of Shifting Sands. Moscow, Ashkhabad. 1979

Olssen-Seffer, P. (1909). Hydrodynamic factors influencing plant life on sandy sea shores. New Phytol. **8**, 37-49.

Rouhipour, H. (1985). Seasonal fluctuations of sand moisture in Khuzestan dune systems unpublished M.Sc thesis. Faculty of Agriculture, Shahid Chamran University of Ahvaz.

Salisbury, E.J. (1952). Downs and Dunes, London: Bell.


Print


Proceedings