Pak. J. Bot., 11(1): 85–91, 1979.

DROUGHT RESISTANCE AND DEW UTILIZATION IN *SORGHUM BICOLOR* (L.) MOENCH. AND *IPOMOEA PES-CAPRAE* (L.) SWEET.

PARVAIZ AKHTAR AND S. SHAHID SHAUKAT

Department of Botany, University of Karachi, Karachi-32.

Abstract

Drought endurance and dew utilization capacity of *Ipomoea pes-caprae* and *Sorghum bicolor* were evaluated.

The angle of contact between dew droplets and leaf surface, that reflects the capability of dew absorption, exhibited a well-marked diurnal fluctuation in both the species. Both were able to survive soil moisture regime below permanent wilting percentage. Exposure of these plants to dew simulation chamber provided concrete evidence of their dew utilization capacity in maintaining their hydrologic balance under soil moisture austerity. The adaptations that enable these plants to withstand arid conditions are discussed.

Introduction

Plants growing in arid conditions face recurrent threats of moisture deficit. Nature has endowed these plants with varied adaptations to withstand low soil moisture regimes. It has been established that dew contributes substantially towards the water economy of such plants by abating the transpirational losses of moisture during sunrise (Slatyer, 1960), through absorption by aerial parts of plants at night (Stone *et al,* 1950; Zohary, 1962; Fritschen & Dorswamy, 1973; Akhtar & Shaukat, 1976) or by stem flow that alleviates the soil moisture tension in the rhizosphere (Shure & Lewis, 1973).

Sorghum bicolor (L.) Moench., is known to withstand austerity of soil moisture and it is likely that capability of dew utilization could be responsible for maintaining its hydrologic balance. On the other hand, *Ipomoea pes-caprae* (L.) Sweet, a coastal sand-binder that plays a pre-eminent role in the stabilization of embryonic dunes (Chaudhri & Qadir, 1958) is subjected to physiological drought owing to preponderance of salts in the rooting medium. Furthermore, high wind velocity prevailing in the coastal region enhances the rate of evapotranspiration imposing upon this plant a continuous struggle to keep its moisture equilibrium within safe limits (Waisel, 1973). Contribution of moisture through foliar absorption, in this case, would likewise be of appreciable value towards its survival and longevity.

In view of these considerations, an investigation was undertaken to ascertain the magnitude of moisture stress tolerance of *Sorghum bicolor* and *Ipomoea pes-caprae* and to assess their capability of dew utilization.

Materials and Methods

One-week-old seedlings of *Sorghum bicolor* (L.) Moench. var. White Hegari and *Ipomoea pes-caprae* (L.) Sweet, were transplanted into earthen pots 30 cm dia. containing sandy loam mixed with farmyard manure (25:1; v/v) @ 10 and 3 seedlings per pot, respectively. The soil used for *I. pes-caprae* contained comparatively greater proportion of sand. Watering of pots containing *S. bicolor* was discontinued after 5 weeks and in those containing *I. pes-caprae* after 11 weeks growth (due to a relatively slow growth rate). The soils reached their Permanent Wilting Percentage (PWP) within a week subsequent to cessation of moisture supply.

Pressure membrane extractor (Soil Moisture Equipment Co., California) was employed to ascertain the PWP of the soils following the method of Richards (1947). Once the PWP was determined the successive observations were made merely by oven drying the soil samples from the rhizosphere at 105°C for 24 h. and comparing the moisture contents with the PWP estimated for each pot.

For the assessment of dew utilization and drought endurance a set of pots was sealed with polythene sheets and water repellent wax to prevent any entry of moisture into the pot soil. During day (12 h) this set was kept in a growth room illuminated with flourescent tubes supplemented with incandescent lamps (total light intensity = 7 K Lux) at 32°C and 55-65% RH. Dew was supplied for 12 h at a rate of 1.76 ± 0.21 mm/night (measured by Hiltner type dew balance) by subjecting the plants to dew simulation chamber (Akhtar & Shaukat, 1976). In a second set, the pots were kept in field conditions at night and in the growth room during day time (12 h). Control plants were maintained in the growth room environment as described for the first set. Night temperature of the growth chamber was kept at 26 ± 1°C. These plants were not supplied with moisture either through soil or in the form of dew and, therefore, not only served as control but also provided the basis for the assessment of relative drought endurance of the two test species.

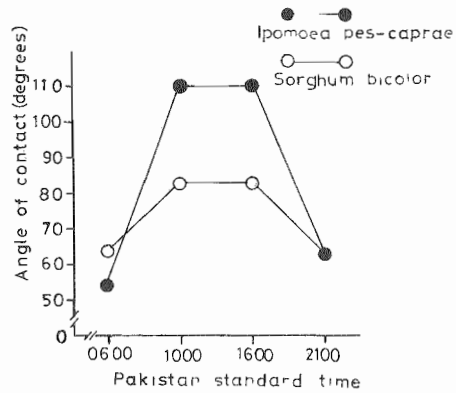

Fig. 1. Measurements (degrees) of angle of contact of dew droplets on the abaxial leaf surfaces of plants rooted in soils at 15 atm. soil moisture tension (PWP).

The angle of contact between the dew droplet and leaf surface was measured following the technique described by Ebeling (1939) when the rooting medium reached its PWP.

Results

1. *Time course study of the angle of contact:*

The diurnal changes in the angle of contact between dew droplets and leaf surface are shown in Fig. 1.*S. bicolor* had an angle of contact of 64° at 0600 hrs that increased to 83° at 1000 hrs. and remained constant upto 1600 hrs. It declined subsequently and at 2100 hrs it was 63°. *I. pes-caprae,* however, exhibited an angle of contact of 54° which rose to 110° at 1000 hrs., remained unchanged at 16000 hrs. and declined to 63° at 2100 hrs.

2. *Study of the role of dew in the survival of plants:*

The control plants of *S. bicolor* (which did not receive moisture), showed no sign of

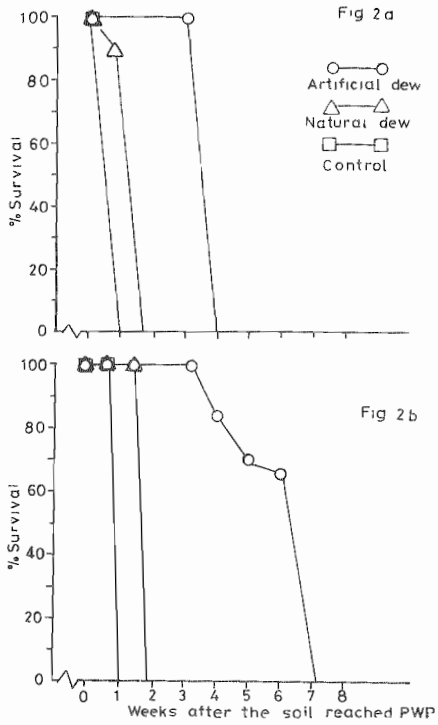

Fig. 2. a & b: Effect of artificial and natural dew on the survival pe centage of *Sorghun. bicolor* (2a) and *Ipomoea pes-caprae* (2b) after the soils reached their PWP. Controls were not supplied with any form of moisture.

growth or development of new leaves. Severe wilting was observed as early as 3 days after the commencement of the experiment. Mortality of most of these plants (more than 80%) occurred on the 5th day. Wilting was discernible on 6th day in the second set (plants exposed to naturally occurring dew). No new leaf sprouted and severe wilting eventually resulted in the death of all of these plants by the 9th day. The plants supplied with artificially produced dew did not show any sign of growth depression and remained healthy upto the 3rd week. These plants exhibited wilting from the 20th day. Eleven new leaves sprouted in 40 plants kept under observations during this period. Mortality of these plants was noticed during the 4th week. However, one plant was able to survive upto 30 days (Fig. 2a).

In case of *I. pes-caprae* the controls showed wilting on the 4th day and no sign of life could be noticed after the 7th day. In the second set, loss of turgidity of the leaves was apparent on the 8th day. This condition resulted in the shedding of basal leaves of the plants. Although some new leaves also developed but they were pale green in colour. Severe wilting was observed from the 10th day which was eventually followed by the death of these plants at the end of second week. A number of new leaves sprouted in the plants subjected to dew simulation chamber. Shedding of basal leaves occurred in the first month. The older leaves turned pale green and this condition became well-marked during the second month with a gradual appearance of wilting symptoms, which became more severe, finally resulting in the mortality of these plants by the end of the second month. No living plant could be found after 50 days. (Fig. 2b).

3. *Assessment of drought resistance:*

The permanent wilting percentage (PWP) of the soil used for *S. bicolor* was found to be 10.2 ± 0.13% (Table 1). The individuals of this species, however, did not exhibit wilting symptoms at this stage but did so when the soil moisture content declined to 7.89 ± 0.14%. Individuals of *I. pes-caprae* wilted when the soil moisture contents reached 7.33 ± 0.11%, whereas the PWP of the soil was 8.49 ± 0.09%.

TABLE 1. Moisture contents of the rooting medium of *Sorghum bicolor* and *Ipomoea pes-caprae* at 15 atm. (PWP) and at the time of plant wilting.

Test plant	Moisture % by weight	
	PWP of the soil	Plants wilted at
Sorghum bicolor	10.21 ± 0.13	07.89 ± 0.14
Ipomoea pes-caprae	08.49 ± 0.09	07.33 ± 0.11

Discussion

I. pes-caprae showed a very high angle of contact during the day (1000-1600 hrs)

presumably owing to the presence of glabrous waxy surface of the leaves which is consequently water repellent in nature. The surface of *S. bicolor* is waxy and it seems that the angle of contact is lowered in response to the scabrous vesture type which appears to act like a porous pad facilitating the droplets to adhere more cohesively to the surface of the leaves.

It has been established that at night when the transpirational pull becomes negligible (Slatyer, 1960), it is taken over by osmotically induced suction pressure in the leaves which rises concurrently with the decrease in the soil moisture contents (Meriaux, 1967). At 2100 hrs. *I. pes-caprae* and *S. bicolor* exhibited a similar degree of wettability. During the day there was a difference of about 27^{o} in the angle of contact measured for the two species. Considering the implementation of suction pressure, a decline of 29^{o} in the angle of contact in *S. biocolor* at night indicates that this species depleted some quantity of soil moisture during the day which eventually resulted in an increased suction pressure in the leaves at night which is supposed to be high enough to bring the angle of contact down to 63^{o}. Similar wettability at night in the case of *I. pes-caprae* would suggest that this species depleted a greater quantity of soil moisture so as to bring the angle of contact 47^{o} lower from that of day time. A similar angle of contact recorded for the two species may seem to indicate the prevalence of a similar suction force in their leaves. Nevertheless, *I. pes-caprae* has to have a suction force in the leaves greater than that of *S. bicolor* to show equal degree of wettabiliy owing to the water repellent force of the waxy leaf surface which alleviates, to a certain extent, the impact of suction pressure of the leaves on the dew droplets.

The rate of transpiration has been shown to decrease with an increase in water stress (Vaadia *et al,* 1961; Jarvis, & Slatyer, 1970; Hsiao, 1973). Since the present investigation was conducted on plants under a soil moisture tension of 15 atm, it is likely, despite their healthy appearance, that both the species did not tolerate this tension equally. Thus, the plant which was least transpiring at 15 atm stress was the one most affected; the reverse being true for relatively rapid transpiring plant (Hsiao, 1973). Consequently the total evapotranspiration rate under similar environment is expected to be relatively greater from the shoot of *I. pes-caprae* in comparison to that of *S. bicolor.*

S. bicolor survived on artificially produced dew upto 26 days without any irrigation to the rooting medium. In contrast, *I. pes-caprae* remained alive for as long as 50 days, indicating a greater capability of utilizing dew. Survival of plants on dew at PWP of soil, observed in this study, is consistent with the findings of earlier workers with other plant species (Stone *et al.,* 1950; Waisel, 1958; Stone, 1952; Akhtar & Shaukat, 1976). However, the plants subjected to natural dewfall survived at PWP for a comparatively short period (not exceeding 10 days for *S. bicolor* and 14 days for *I. pes-caprae)* because of meagre dewfall that was estimated to be 0.017 ± 0.006 mm/night (Akhtar, 1974). On the other hand, heavy dew formation in the simulation chamber can undoubtedly be accounted for the survival of both the species for a relatively much greater duration.

After indirectly assessing the capability of dew absorption, by measuring the angle

of contact, a test of tolerance was carried out to determine the drought resistance capacity of the plants under consideration. No symptom of wilting was observed in the plants of both the species rooted in the soil at PWP. This finding corroborates the concept that PWP is not strictly a property of the soil only since some plants are more efficient than others in extracting soil water (Slatyer, 1957; Sykes & Loomis, 1967).

I. pes-caprae survived 2 days longer but depleted 9.16% lesser soil moisture than did *S. bicolor* under the same environment. At first sight it would appear that this result is contrary to that suggested by the time course study of the angle of contact. A close parallel cannot be drawn between the moisture depletion of soil under stress condition and the angle of contact that is governed by leaf morphology on one hand and soil moisture regime on the other. Nonetheless, it appears that the major factor responsible for the survival of *I. pes-caprae* for a longer duration, with a lesser degree of soil moisture depletion, would be the fleshy nature of the leaves that have stored water. At soil moisture stress of 15 atm and above, the root system of *I. pes-caprae* could not extract much moisture but the plant was able to survive by consuming the stored water.

Field observations on *I. pes-caprae* suggest the plastic nature of its leaves, the leaf thickness varying directly with the magnitude of moisture stress. This phenotypic plasticity and the capability of dew absorption through the leaf surface despite the presence of thick cuticle (Turrel, 1947, Frey-Wyssling & Muhlethaler, 1959) appear to be the chief factors responsible for its drought endurance. On the other hand, the sunken stomates, scabrous vesture type, rigidity of conducting tissue of *S. bicolor* and the faculty of dew utilization appear to be the principal reasons for its remarkable drought resistance capacity.

References

Akhtar, P. 1974. Investigations on dew as an ecophysiological factor with special reference to drought resistance capacity of certain plants. M. Sc. thesis, Karachi University.

Akhtar, P. and S.S. Shaukat. 1976. Role of dew in the survival and phenology of *Gossypium hirsutum* L. Cv. Qalandri Pak. J. Bot., 8: 151–155.

Chaudhri, I.I. and S.A. Qadir. 1958. Sand dune vegetation of coastal regions of Karachi. Pak. J. For., 8: 337–341.

Ebeling, W. 1939. The role of surface tension and contact angle in the performance of spray liquids. Hilgardia, 12: 665–698.

Frey-Wyssling, A., and K. Muhlethaler. 1969. Uber des submikroskopische Goschehen beider kutinisierungjpflanzlicher Zellwande. Naturf Geselling Zurich. Vutljschr, 104: 294–299.

Fritschen, J. L. and P. Doraiswamy, 1973. Dew: An addition to the hydrologic balance of Douglas Fir. Water. Resour. Res., 9: 891–894.

Hsiao, T.C. 1973. Plant responses to water stress. Ann. Rev. Plant Physiol., 24: 519–570.

Jarvis, P.G. and R.O. Slatyer. 1970. The role of mesophyll cell wall in leaf transpiration. Planta, 90: 303–322.

Meriaux, S. 1967. Physiological meaning of the suction pressure of leaves with respect to the ecology of the plant. Ann. Agron., 18: 639–651.

Richards, L.A. 1947. Pressure membrane apparatus construction and use. Agri. Eng., 28: 451–454.

Shure, D. J and A J. Lewis, 1973. Dew formation and stem-flow on common ragweed. Ecology, 54: 1152 1155.

Slatyer, R.O. 1957. The influence of progressive increase in total soil moisture stress on transpiration, growth and internal water relationships of plants. Aust. J. Biol. Sci., 10: 320–336.

Slatyer, R.O. 1960. Absorption of water by plants. Bot. Rev., 26: 331–392.

Stone, E.C., F.W. Went and C.L. Young. 1950. Water absorption from the atmosphere by plants growing in dry soil. Science, 3: 546–548.

Stone, E.C. 1962. The role of dew in pine survival in soils below wilting point and its measurements. Proc. Int. Symp. Arid Zone Res. 25. Methodology of Plant Eco-physiology, Montpellier, France. April 1962. UNESCO, Paris, 421–427. 1965.

Sykes, D.J. and W.E. Loomis. 1967. Plant and soil factor in permanent wilting percentage and field capacity storage. Soil. Sci., 97: 104 173.

Turrel. F. M. 1947. Citrus leaf stomata: Structure, composition and pore size in relation to penetration of liquids. Bot. Gaz., 108: 476–483.

Vaadia, Y., F.C. Raney, and R.M. Hagen. 1961. Plant water deficits and physiological processes. Ann. Rev. Plant Physiol., 12: 265–292.

Waisel, Y. 1958. Dew absorption by plants of arid zones. Bull. Res. Counc. Israel, 6D: 180–186.

Zohary, M. 1962. Plant life of Palestine, Israel and Jordan. The Ronald Press. Co. N.Y. pp. 262.