Yüzüncü Yıl Üniversitesi, Ziraat Fakültesi Dergisi, 1996, *6* (1): 185-190. ISSN 1018-9424

EFFECT OF SOIL WATER POTENTIALS ON THE WATER RELATIONS OF SOME DROUGHT RESISTANT PLANTS

İBRAHİM YILMAZ[1]

(DERLEME)

ABSTRACT: The term permanent wilting point have long been used to describe the lower limit of soil moisture in the soil water reservoir. It is the water content of the soil below which water can not be extracted by plants and often taken as the water content of the soil at -1.5 MPa (-15 bar) water potential for most of plants. However, there are a number of desert plants which have the ability of taking water from the soil at much lower than -15 bar. Therefore, permanent wilting point is not valid for some desert and halophytic species, they must be able to endure and grow in soils where the soil water potential is seldom -15 to -20 bars.

Key words: Soil water potential, permanent wilting point, drought resistant species, soil water relationship

KURAĞA DAYANIKLI BAZI BİTKİLERİN SU İLİŞKİLERİNDE TOPRAK SU POTANSİYELİNİN ETKİSİ

ÖZET: Devamlı solma noktası terimi bitkilerin topraktan yararlanabileceği en düşük su limitini tarif etmek amacı ile kullanılagelmiştir. Toprağın su muhtevası bundan daha da aşağı düşerse bitkiler o sudan faydalanamazlar Çoğu bitkiler için devamlı solma noktası -1.5 MPa (-15 bar)'daki toprağın su muhtevası olarak bilinmektedir. Halbuki, birçok çöl bitkileri ve halophytic türler -15 bar'dan daha düşük basınçla tutulan sudan yararlanabilmektedirler. Bu yüzden devamlı solma noktası bazı çöl bitkileri ve halophytic türler için geçerli değildir ve bu bitkiler toprağın su potansiyelinin çok nadir olarak -15 ile -20 bar olduğu şartlara dayanmak ve büyümek zorundadırlar.

[1] Yüzüncü Yıl Üniversitesi, Ziraat Fakültesi, Tarla Bitkileri Bölümü, 65080 -VAN

INTRODUCTION

The terms field capacity and permanent wilting point (1) have long been used to describe the upper and lower limits of soil moisture in the soil water reservoir. Field capacity is used to denote the water content of soil when the rate of change of water content in the profile becomes slow following a rain or irrigation. Permanent wilting point is the water content of the soil below which water can not be extracted by plants. Field capacity and permanent wilting point are often taken as the water content of the soil at -0.033 and -1.5 MPa (-1/3 bar and -15 bar) water potential. However, there are a number of desert plants and halophytic species which have the ability of taking water from soil at much lower than -15 bars. Gardner et al. (2) have determined for a desert soil, where negligible loss rates are much lower, the field capacity water potential as -1 bar and permanent wilting point as -50 bar. Also, they explained that between -15 bar and -50 bar, an additional 15 percent, or 30 mm of water per meter of rooting depth, is made available. In other word, while most of plants can not use that water, it is available for desert species.

At desert conditions, most rainfall occurs in small storms of short duration and much of moisture may evaporate from the upper soil horizons within a short time after these rainstorms. Sammis and Gay (3) have determined that as much as 93% of the annual incident precipitation is lost by evaporation in creosote bush desert. Therefore, desert species must be able to endure and grow in soils where the soil water potential is seldom -15 to -20 bars. On the other hand, some halophytic species have been growing under saline soil conditions which have seldom -15 bars soil water potentials. Waisel and Pollak (4) have shown under field conditions that several halophytic species of Israel were able to grow at soil water potentials of -35 to -50 bars.

This paper is going to try explain that permanent wilting point which is -15 bar soil water potential for most of plants is not valid for some drought resistant species as well as their water relation characteristics.

EFFECT OF SOIL WATER POTENTIAL ON WATER ABSORBSITION OF SOME DROUGHT RESISTANT PLANTS

Sosebee and Wan (5) have studied the effects of soil water deficit on root growth, carbon allocation and plant mortality of broom snakeweed (***Gutierrezia sarothrae***) during the spring-summer growing season in plants subjected to different soil water regimes at Texas Tech research areas. They found that broom snakeweed plants died at an average water content of 0.03 g/g in the top 20 to 30 cm of the soil profile on the sandy loam soil, which was equivalent to a soil water potential of -75 bars. That time the leaf relative water content was about 0.50. They point out that when plants exposed to a soil water potential of lower than -19 bars for some period of time, some mortality will occur, however the major die-off will not take place until soil water potential is further reduced to -75 bar They also indicated that root/shoot ratio remained unchanged as soil water potential decreased from -0.23 bar to -19 bars; but it became higher when soil water potential decreased to -34 bars, indicating that root growth is favored over shoot growth at lower soil water potentials.

William et al. (6) studied soil moisture content and plant transpiration in the Chihuahuan desert of New Mexico during 1983 and 1984 years. At the study area the vegetation was dominated by creosote bush (***Larrea tridentata***), with ***Gutierrezia sarothrae***, ***Zinnia acerosa*** and ***Opuntia phaeacantha***. They established two plots (control and harvested) to compare lossing of water by transpiration. They determined soil water potential for three depth (7, 35, and 70 cm) at control plots during 1983 and 1984 years. During those years, all three depth of soil had soil water potentials much lower than -1.5 MPa most of time. Especially, in the summer time all horizons had lower than -7 MPa (-70 bar) soil water potential. They obviously determined that this vegetation can get water from soil much lower than -15 bar most of time. Besides, they determined that 72% of incident precipitation is removed by plant transpiration in this ecosystem. Odening and Strain et al. (7) found similar results either. They found stomatal closure (zero net photosynthesis) at -7.5 MPa for ***Larrea tridentata*** in laboratory experiment. They also determined in the Sonoran desert that transpiration of ***Larrea tridentata*** declines linearly between -5 and -6 MPa of plant water potential. Moore and White et al. (8) did similar experiment for cold desert species in Utah, they found that transpiration decreased linearly with a decline in soil water potential in the range from -3 to -8 MPa. Transpiration rate is decreased linearly with decreasing soil and plant water potentials, but the interesting point is that, ***Larrea tridentata*** and some cold desert species are still transpiring at much lower than -1 5 MPa soil water potentials, despite the other plants can not do that at all

Another interesting study has been done by Moore et al (8) They studied transpiration of ***Atriplex confertifolia*** and ***Eurotia lanata*** in relation to soil, plant and atmospheric moisture stresses in the field and laboratory under controlled conditions. At this study, they indicated that under both field and laboratory conditions, vapor pressure deficit and water stress were significant factors influencing transpiration. Under laboratory conditions both species exhibited transpiration at plant moisture stress values as great as -115 bars and transpiration particularly at 30 and 40° C, decreased almost linearly with decreasing soil water potentials under conditions of moderate and severe moisture stress, -20 to -30 bars and -45 to -60 bars respectively. Moreover, both species under field and laboratory conditions showed transpiration beyond -70 to -80 bars. ***Atriplex confertifolia*** showed transpiration at plant water potentials as great as -96, -97 and -114 bars and ***Eurotia lanata*** showed transpiration at plant water potentials -95, -105, and -120 bars respectively, indicating that soil water potentials are much lower than -15 bar, but those plants are still alive and transpiring. Palmer et al (9) reported similar results for ***Atriplex nummularia***. This plant had decreasing transpiration rate within the soil water potential range of -10 to -60 bars. Again this interval is much lower than -15 bar, however, ***Atriplex nummularia*** is still transpiring.

EFFECT OF SOIL WATER POTENTIAL ON SOIL WATER ABSORPTION OF SOME HALOPHYTIC SPECIES

Other drought resistant plants are halophytic species. Waisel and Pollak (4) have shown under field conditions that several halophytic species of Israel were able to grow at soil water potentials of -35 to -50 bars. They did experiment under non-saline soil laboratory conditions and saline soil field conditions. Under non-saline soil laboratory conditions sunflower and tomato which are unhalophytic species and ***Aeluropus litrolis*** and ***Sueda monoica*** which are halophytic species showed wilting symptoms at almost same soil water potentials. However, the stresses endured usually in the field by these halophytes were far above this point. Stresses at equilibration point (the wilting point) found under saline soil field conditions corresponded to water potentials between -0.3 and -50 bars. Therefore, they explained that the restriction of the wilting point, to the -15 bars range, is valid only for glycophytes or halophytes growing under non-saline soil conditions. Under saline soil conditions the wilting point of halophytes is far above water stresses of -15 bars.

Very limited supply of water under desert conditions effects water relations of plants considerably. Bokhari et al. (10) determined soil water potentials of desert vegetation at three locations of Saudi Arabia (Sauthwestern, eastern and central). At southwestern location, they determined -30 bar soil water potential at vegetative and flowering stages of desert species which are ***Andropogen distachyus***, ***Chrysopogen plumuiosus***, ***Eragrostis braunii***, ***Themeda triandra***, and ***Hyperrhenia hirta***. On the other hand, they determined -50 bars soil water potential at eastern and central location at vegetative and flowering stages of desert species which are ***Panicum turgidum***, ***Astenatherum fragilis***, ***Stipagrostis plumosa***, and ***Panicum turgidum***. Those desert vegetation soil water potentials are much lower than -15 bars and those desert species are already growing under very limited water supply conditions without showing wilting symptoms. Also, the researchers explained that eastern and central locations had soil water potentials lower than southwestern because of climatic factors and soil salt concentration. Again, under saline soil conditions, desert plants take water from soil at soil water potential much lower than non-saline soil water potential.

Another study about a cold winter shrub, ***Atriplex confertifolia*** has been done by Hodgkinson et al.(11). They applied two treatments to ***Atriplex confertifolia*** plants, control and 25 mm of supplementary water. Control and 25 mm supplementary treatments had soil water potential much lower than -15 bars for 4 depth of soil which are 7.5, 15, 22.5, and 50 cm during summer season. Even at 50 cm depth of soil, soil water potentials was lower than -15 bars during summer. Control treatments represent natural condition in which ***Atriplex confertifolia*** has been growing. This can clearly show us, ***Atriplex confertifolia*** can survive at soil conditions where soil water potential is seldom higher than -15 bars. At this study, watering of the soil only reduced plant water stress from -30 to -15 bars

RESULT

As a result, permanent wilting point which is equivalent to -15 bars soil water potential is not valid for some desert, halophytic, and weed species. They can survive at soil water potentials much lower than -15 bars. Despite most of crop plants can not use soil water which is hold by soil particles lower than -15 bars, it is available for some desert and halophytic species, however, that does not make them much productive.

LITERATURE CITED

1. Daubenmire, R. 1959. Plants and Environment. John Wiley, New York. 422p.

2. Gardner, W. R., D. Hillel, and Y. Benyamini. 1970. Post irrigation movement of soil water. I Redistribution. Water Resour. Res. 6: 851-861.

3. Sammis, T., and L.W.Gay, 1979. Evapotranspiration from an arid zone plant community. Journal of Arid Environments, 2: 313-321.

4. Waisel, Y. and Pollak. 1969. Estimation of water stresses in the active root zone of some native halophytes in Israel. J. Ecol. 57: 789-794.

5. Sosebee, R. E. and W. Changgui, 1991. Physiological responses of ***Gutierrezia sarothrea*** to soil water deficit, part II effects of stress on carbon allocation, root growth, and plant mortality. (Unpublished data)

6. William H. S., J. F. Paul and M. M. Giles,1987. Soil moisture content and plant transpiration in the Chihuahuan Desert of New Mexico. Journal of Arid Environments. 12: 119-126.

7. Odening, W. R., B. R. Strain and W. C. Oechel,.1974. The effect of decreasing water potential on net CO_2 exchange of intact desert shrubs. Ecology, 55: 1086-1095.

8. Moore, R. T., R. S. White and M. M. Caldwell, 1972. Transpiration of ***Atriplex confertifolia*** and ***Euratia lanata*** in relation to soil, plant, or atmospheric moisture stresses. Canadian Journal of Botany, 50: 2411-2418.

9. Palmer, J. H., E.S. Thickett, and E. T. Linacre, 1964. Transpiration response of ***Atriplex nummulari*** Lindl. and upland cotton vegetation to soil moisture stress. Agric. Meteorol., 1: 282-293.

10. Bokhari, U. G., F. Alyaeesh and M. Al-Nori. 1987. Adaptive strategies of desert grasses in Saudi Arabia. J. Range Manage., 40 (1): 19-22.

11. Hodgkinson, K. C., P. S. Johnson and B. E. Morton. 1978. Influence of summer rainfall on root and shoot growth of a cold winter desert shrub, ***Atriplex confertifolia***. Oecologia, (Berl.) 34, 353-362.