Efficiency of water use for sorghum, beans, and sesame affected by ground water table

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Abstract
Pot experiments using lysimeters with 5 depths of ground water table (GWT); 0, 25, 50, 75, and 100cm, respectively were conducted to investigate crop biomass, water use efficiency, and changes of soil moisture for sorghum, beans and sesame. All the lysimeters were randomized with four replication arrangements were filled up with soils and were adjusted to constant bulk density, treated twice water infiltration from bottom to top of lysimeter. Dry weight of above ground part of sesame was gradually increased with deeper GWT showing the highest in the plot of 100cm GWT. Beans had the highest tolerance against excess moisture condition while sesame showed the lowest tolerance being a serious obstacle to crop growth. Water use efficiency of the experimental crops in condition of saturated soil was significantly decreased compared with normal moisture condition of soils. Consequently estimation of GWT for maximum amount of evapotranspiration was 35.6cm, 16.5cm, and 9.6cm for sorghum, sesame, and beans, respectively.

Key Words
Lysimeter, evapotranspiration, sorghum, beans, sesame, ground water table, water use efficiency.

Introduction
Evapotranspiration information is required for many applications in agricultural and natural resource management from hydrological applications to plant growth and yield models to irrigation scheduling recommendation. Early observations of diurnal shallow water table fluctuation were made by White (1932), Troxell (1936), and Meyboom (1967). White (1932) proposed a method that utilizes observation of shallow water table fluctuation to estimate the direct consumption of groundwater by plants. Even lysimeters that are used for measuring water use by irrigated crops were found to give inaccurate estimates of evapotranspiration when the state. The object of this paper is to evaluate crop biomass and water use efficiency such as evaporation and evapotranspiration affected by shallow ground water table conditions ranging from 0 cm to 100 cm.

Material and methods
Lysimeter controlled with 5 depths of ground water table; 0, 25, 50, 75, and 100 cm, respectively was made by PVC pipe with 30 cm diameter to investigate crop biomass, water use efficiency, and changes of soil moisture for Sorghum, Beans, and Sesame cultivation. All the lysimeters were randomized with four replications were filled with soils and adjusted to constant bulk density by water infiltration from bottom to top of the lysimeter. The seedlings (17 days after seeding) of Sorghum, Beans, and Sesame were transplanted on May 7, 2007 and harvested on July 12, 2007 for Sorghum and on July 23, 2007 for Beans and Sesame. Evaporation from lysimeter grown without crop and evapotranspiration form lysimeter grown with crop were measured everyday by amount of water consumption in water supplying bottle. Therefore transpiration was calculated by difference between evapotranspiration and evaporation measurement. Also bulk moisture content of soils during the growing season was measured by TDR sensor installed at different soil depth from surface with 25cm interval. Air temperature and humidity during the growing season were measured by data logger with a 30 minute interval.

Results
Dry weight of above ground part of sesame gradually increased with deeper GWT being the highest in the plot of 100cm GWT. Dry weight of sorghum was the highest in the plot of 50cm GWT showing the following order of 75cm>100cm>25cm GWT while that of beans was the highest in the plot of 25cm GWT showing the following order of 0cm>50cm>75cm>100cm GWT. Beans have the highest tolerance against excess moisture condition while sesame showed the lowest tolerance showing a serious obstacle in crop growth (Table 1).

Table 1. Above-ground dry matter of crops affected by different ground water table.

Crop	Growth period	GWT-0cm		GWT-25cm		GWT-50cm		GWT-75cm		GWT-100cm	
		DW	Index	DW	Index	DW	Index	DW	Index	DW	Index
Sorghum	66days	93.1	56.7	161.4	98.1	220.1	130.8	180.9	113.9	175.1	100.0
Sesame	77days	81.7	55.7	114.7	74.9	112.1	61.6	124.9	72.8	179.8	100.0
Beans	77days	189.8	141.2	248.7	174.5	186.6	124.2	150.3	94.7	151.7	100.0

Evapotranspiration ratio calculated by total amount of evapotranspiration (g) per dry weight of above ground part (g) in the plot of 100cm GWT were 82, 195, 178 for sorghum, sesame, and beans, respectively compared with 275, 420, 293 in the plot of 0cm GWT, respectively. Consequently water use efficiency of the experimental crops in condition of saturated soil was significantly decreased compared with normal moisture condition of soils (Table 3). Consequently estimation of GWT for maximum amount of evapotranspiration were 35.6 cm, 16.5 cm, and 9.6 cm for sorghum, sesame, and beans, respectively (Table 4)

Table 2. Total amount of evaportranspiration affected by different GWT during the growing seasen.

Crop	GWT-0cm (L/lysimeter^{-1})	GWT-25cm (L/lysimeter)	GWT-50cm (L/lysimeter)	GWT-75cm (L/lysimeter)	GWT-100cm (L/lysimeter)
Sorghum	24.83	29.74	30.27	22.89	14.45
Sesame	27.49	40.37	21.77	15.06	15.56
Beans	54.75	63.64	52.28	32.75	27.00

Table 3. Evapotranspiration ratio affected by different GWT during the growing season.

Crop	GWT-0cm	GWT-25cm	GWT-50cm	GWT-75cm	GWT-100cm
Sorghum	275	168	138	130	82
Sesame	420	396	260	196	195
Beans	293	261	280	209	178

*Evapotranspiration ratio was calculated by above-ground dry matter (g) / total amount of evapotranspiration (g)

Table 4. Optimum ground water table for maximum evapotranspiration of crop.

Crop	Regression equation (0cm < X < 100cm)	Ground water table at maximum evapotranspiration
Sorghum	Y=-0.004x2+0.285x+25.015	35.6
Sesame	Y=-0.0015x2-0.0494x+32.043	16.5
Beans	Y=-0.0043x2+0.0825x+58.01	9.6

Conclusion

Dry weight of above ground part of sesame was gradually increased with deeper GWT showing the highest in the plot of 100cm GWT. As the results, beans have the highest tolerance against excess moisture condition while sesame showed the lowest tolerance showing a serious obstacle in crop growth. And water use efficiency of the experimental crops in condition of saturated soil was significantly decreased compared with normal moisture condition of soils.

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