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WATER UPTAKE BY VARIOUS CROPS FROM DIFFERENT SOIL DEPTHS UNDER MOISTURE STRESS CONDITIONS

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Field experiments were conducted on potato, sorghum, berseem and barley from 1983 to 1985 to see the effect of different water stress levels on soil water uptake from various soil depths. Maximum water was absorbed from 0-30 cm soil layer by all the crops regardless of the water stress level. Differential response of crops to moisture stress conditions was observed. Moisture absorption from the lower soil depths was low in case of potato compared to sorghum, berseem and barley. Contribution from lower depth (120-150 cm) for berseem crop was increased with an increase in moisture depletion level.

INTRODUCTION

Water is the most important growth limiting factor in agriculture. It's deficiency may be due to unexpected dry period or normally low rainfall necessitating regular irrigation to ensure profitable crop production. Water deficit may cause reduction in cellular growth, inhibition of chlorophyll production and disturbance in enzyme activities etc. (Salisbury and Ross, 1985).

The factors affecting water absorption by the plant roots include temperature, osmotic potential of the soil solution, aeration and availability of soil moisture. Although the atmospheric conditions affect water absorption, yet conditions prevailing in the soil both the osmotic and matric (Hao and Jong, 1988) are generally the factors limiting absorption of water by the plant roots. As soil water in the vicinity of the root system is depleted, its absorption by the plant roots becomes more and more difficult.

Plants exposed to water stress conditions behave differently to overcome the problem of limited water availability. Some plants change their root development and others limit transpiration by regulating stomatal opening and closure (Newell and Wilhelm, 1987). Huck *et al.* (1983) indicated that water stressed plants produced more extensive root system, whereas irrigated plant produced larger shoots and smaller root system. Larger root systems generally absorb sufficient water to meet the shoot transpiration demand. During drought, due to high matric potential at the surface, the crops extracted water from deeper soil layers (van Schiflgaard *et al.,* 1974; Ingvalson *et al.,* 1976). Mayer and Green (1980) studied the relationship of potential evapotranspiration with root development and observed that at same potential evapotranspiration value, the plants with well developed root systems extracted 80% of the plant available water and the plants with less developed root system extracted 70% of the available water. The present experiments were conducted for estimation of water requirements of different crops.

MATERIALS AND METHODS

The research work was conducted at the farmers' field during 1983 to 1985 on potato, sorghum, berseem and barley. Different water stress levels were developed for crops ranging from 50 to 95% depletion of available water (water content between field capacity and permanent wilting point) except the potato crop. The available moisture depletion levels for potato ranged from 40 to 85%. Irrigations were applied when the desired water depletion level was developed in the upper 30 cm of soil depth. Measured volume of water applied to bring the soil moisture level at field capacity as minimum seepage losses are expected at this level. The volume of water applied to respective crops under different moisture depletion levels was estimated by using the formulae proposed by Shahid (1982):

$$d = \frac{Pm}{100} \times As \times D$$

where

d = Centimeters of water

Pm = Per cent moisture on dry weight basis

As = Apparent specific gravity or bulk density

D = Depth of soil column in centimeters

Flow of water was measured with the help of cut throat flume by installing it in the water channel. Time required for water application was calculated by using the relationship:

$$t = 27.53646 \frac{d \times a}{q}$$

where

t = Time required to irrigate in hours

d = Depth of water to be applied in cm

a = Area in hectares

q = Discharge in litres per second

Gravimetric moisture contents (moisture content calculated by oven drying known weight of soil sample at 105 °C for 24 hours) were determined to a depth of 150 cm in 30 cm increments from plots before and after each irrigation. Soil samples were always taken from previously non-sampled sites. The soil moisture contents were also checked after every rain exceeding 13 mm and contribution to soil moisture was recorded. Water absorption from different soil depths was calculated by subtracting the soil moisture contents before irrigation from the moisture content of different soil depths after each irrigation. The total water absorbed (evapotranspirated) by various crops during the growing season from different soil depths was calculated by summing the values of water absorbed between the irrigation intervals. Data were analysed by using completely randomised block design (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Water absorbed from different soil layers under different water stress conditions by potato, sorghum, berseem and barley is presented in Tables 1, 2, 3 and 4, respectively. The data revealed that maximum water absorption occurred from the upper 30 cm of soil depth for all the crops regardless of the water stress level. Garay and Wilhelm (1983) and Huck *et al.* (1983) pointed out that different plant species react differently to water stress. Morphology and phenology of plants play a major role in this respect. The interaction of water stress levels with soil depths was also highly significant.

Potatoes absorbed significantly more water (11.9, 11.2, 9.3 and 7.9 cm under M_1, M_2, M_3 and M_4, respectively) from the upper soil layer (0-30 cm) even under stress conditions. Contribution from lower depths

Table 1. Effect of water stress on water absorption from different soil depths by potato

Soil depth (cm)	Moisture regime				Means
	M_1	M_2	M_3	M_4	
0-30	11.9 a	11.2 b	9.3 c	7.9 d	10.1 a
30-60	6.2 e	6.1 e	5.2 f	5.3 f	5.7 b
60-90	3.2 g	2.9 gh	3.0 g	4.3 fg	2.9 c
90-120	2.0 ij	1.6 j	2.1 i	1.1 k	1.7 d
120-150	0.02 l	0.02 l	0.02 l	0.02 l	0.02 e
Means	4.6 a	4.3 b	3.9 c	3.3 d	

Figures followed by different letter(s) are statistically different at P = 0.05.

Table 2. Effect of water stress on water absorption from different soil depths by sorghum

Soil depth (cm)	Moisture regime				Means
	M_1	M_2	M_3	M_4	
0-30	7.1 a	6.6 b	5.5 cd	5.1 de	6.1 a
30-60	5.8 c	5.5 cd	5.2 de	5.5 cd	5.5 b
60-90	4.7 ef	4.1 g	4.3 fg	4.1 g	4.3 c
90-120	3.9 gh	3.4 hi	3.2 i	3.1 ij	3.4 d
120-150	2.62 jk	2.72 jk	2.3 k	1.3 l	2.2 e
Means	4.9 a	4.5 b	4.1 c	3.9 d	

Figures followed by different letter(s) are statistically different at P = 0.05.

Table 3. Effect of water stress on water absorption from different soil depths by berseem

Soil depth (cm)	Moisture regimes				Means
	M_1	M_2	M_3	M_4	
0-30	21.1 a	17.3 b	14.6 c	12.2 d	16.3 a
30-60	12.2 d	11.1 e	9.9 f	8.8 g	10.5 b
60-90	8.3 h	7.4 i	6.5 j	7.1 i	7.3 c
90-120	6.0 k	4.4 l	3.2 m	4.4 l	4.5 d
120-150	2.1 p	2.5 o	2.6 no	2.9 n	2.5 e
Means	10.0 a	8.5 b	7.4 c	7.1 d	

Figures followed by different letter(s) are statistically different at P = 0.05.

Table 4. Effect of water stress on water absorption from different soil depths by barley

Soil depth (cm)	Moisture regimes				Means
	M_1	M_2	M_3	M_4	
0-30	15.6 a	13.0 b	10.4 c	7.7 g	11.7 a
30-60	10.4 c	9.7 d	9.1 e	7.5 gh	9.2 b
60-90	8.3 f	7.2 h	6.7 i	5.6 j	6.7 c
90-120	5.0 k	4.5 l	3.7 m	3.3 n	4.1 d
120-150	2.6 o	2.1 p	1.8 pq	1.6 q	2.0 e
Means	8.4 a	7.3 b	6.4 c	5.1 d	

Figures followed by different letter(s) are statistically different at P = 0.05.

(90-120 and 120-150 cm) was very low under all the moisture stress levels.

Sorghum crop absorbed maximum water (7.7, 6.6 and 5.5 cm) from upper 30 cm soil depth under M_1, M_2 and M_3, respectively which was significantly higher from underlying layers. In M_4 moisture depletion level, however, sorghum crop absorbed significantly higher water (5.5 cm) from 30-60 cm soil depth compared to water absorbed (5.1 cm) from 0-30 cm soil depth. Similar trend of water absorption from soil was observed in case of berseem and barley crops. Water absorbed by berseem from 0-30 cm soil depth was 21.1, 17.3, 14.6 and 12.2 cm under M_1, M_2, M_3 and M_4 moisture levels, respectively which was significantly higher from the volume of water absorbed from the underlying depths. Data further revealed that with an increase in moisture stress, the contribution from the lower depths increased. High matric potential in the surface layer between irrigation intervals might have forced the plants to absorb water from lower layers (Ingvalson *et al.,* 1976; Hao and Jong, 1988). Barley crop absorbed significantly higher volume of water i.e. 15.6, 13.0, 10.4 and 7.7 cm from 0-30 cm soil depth under M_1, M_2, M_3 and M_4, respectively. Water absorption decreased with an increase in soil depth under all the moisture stress levels.

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