PLANT WATER STRESS FREQUENCY

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Long-term temperature and precipitation at Dickinson, ND.			
	Mean Monthly Temperature		Monthly Precipitation
	°F		inches
Jan	11.24		0.42
Feb	15.25		0.40
Mar	26.06		0.72
Apr	41.55		1.42
May	52.77		2.32
Jun	61.97		3.59
Jul	68.66		2.24
Aug	66.96		1.74
Sep	56.03		1.32
Oct	43.79		0.95
Nov	28.32		0.54
Dec	17.04		0.39
Mean	40.80 °F	Total	16.06 inches

Seasonal precipitation	Inches	Percent
Average Annual Precipitation	16.06	
Growing Season (Apr-Oct)	13.58	(84.56%)
Apr, May, Jun, Jul	9.57	(59.59%)
Aug, Sep, Oct	4.01	(24.97%)
Nongrowing Season (Nov-Mar)	2.47	(15.38%)

Water Stress

Plants in water stress have limited growth and herbage biomass accumulation. Plant water stress develops in plant tissue when the rate of water loss through transpiration exceeds the rate of water absorption by the roots. Water stress can vary in degree from a small decrease in water potential, as in midday wilting on warm, clear days, to the lethal limit of desiccation. Early stages of water stress slow shoot and leaf growth. Leaves show signs of wilting, folding, and discoloration. Tillering and new shoot development decrease. Root production may increase. Senescence of older leaves accelerates. Rates of cell wall formation, cell division, and protein synthesis decrease. As water stress increases, enzyme activity declines and the formation of necessary compounds slows or ceases. The stomata begin to close; this reaction results in decreased rates of transpiration and photosynthesis. Rates of respiration and translocation decrease substantially with increases in water stress. When water stress becomes severe, most functions nearly or completely cease and serious damage occurs. Leaf and root mortality induced by water stress progresses from the tips to the crown. The rate of leaf and root mortality increases with increasing stress. Water stress can increase to a point that is lethal, resulting in damage from which the plant cannot recover. Plant death occurs when meristems become so dehydrated that cells cannot maintain cell turgidity and biochemical activity.

1892 to 2005	114 years	
Months with Water Deficiency	32.7%	2.0 months/year
Growing Seasons with no Water Deficiency	6.1%	1 yr in 16.3 years
Dry Growing Seasons	15.8%	1 yr in 6.3 years
Wet Growing Seasons	17.5%	1 yr in 5.7 years
Normal Growing Seasons	66.7%	1 yr in 1.5 years

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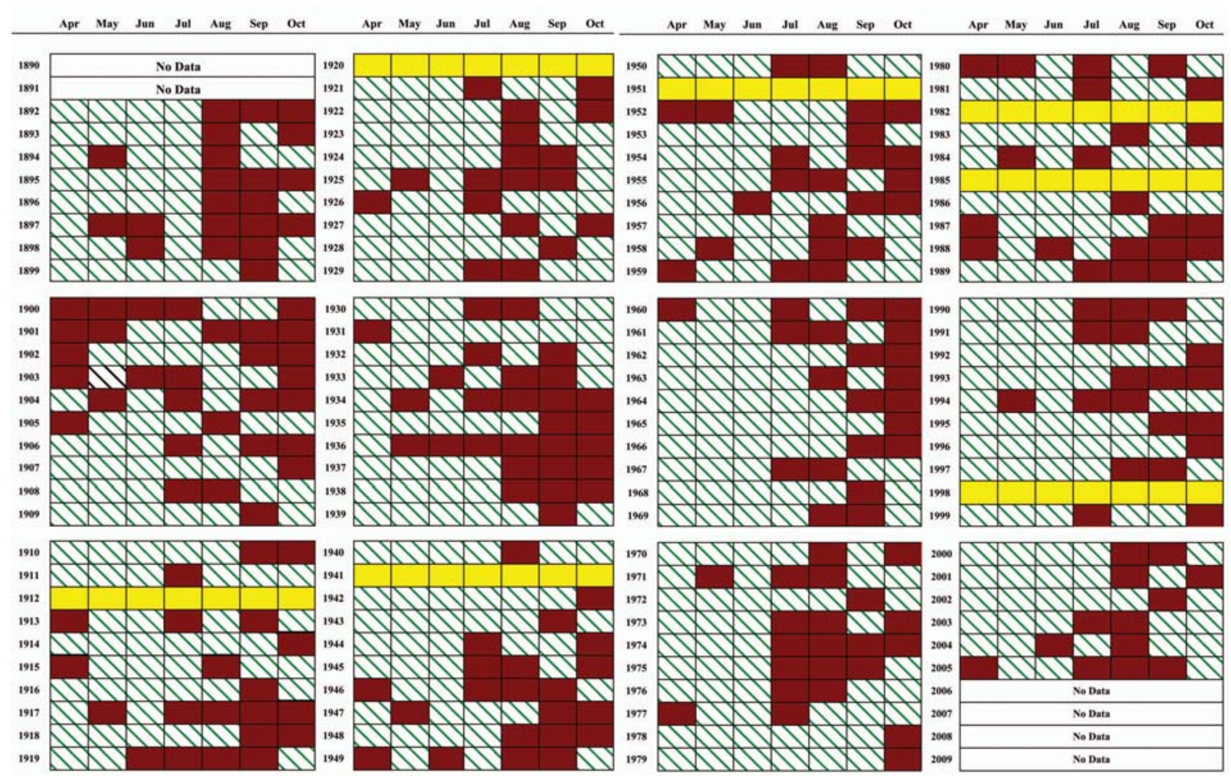
Plant water stress develops during periods of water deficiency because plants are unable to absorb adequate water to match the transpiration rate. A water deficiency exists when the amount of rainfall is less than potential evapotranspiration. Water deficiency conditions are identified by the ombrothermic graph technique (Emberger et al. 1963).

The frequency of water stress conditions has been decreasing during the current weather cycle (1892-2005). Water stress occurred, on an average, 2.2 months per year during 1892 to 1919; the frequency decreased to 2.0 months per year during 1920 to 1949; water stress occurrence decreased to 1.9 months per year during 1950-1979; and the frequency of water stress decreased to 1.8 months per year during 1980 to 2005.

The region has had only 7 growing seasons in 114 years (6.1%) that have not had water stress. Three of these have occurred since 1980.

Growing Season Months with Water Deficiency Conditions that caused Water Stress in Perennial Plants

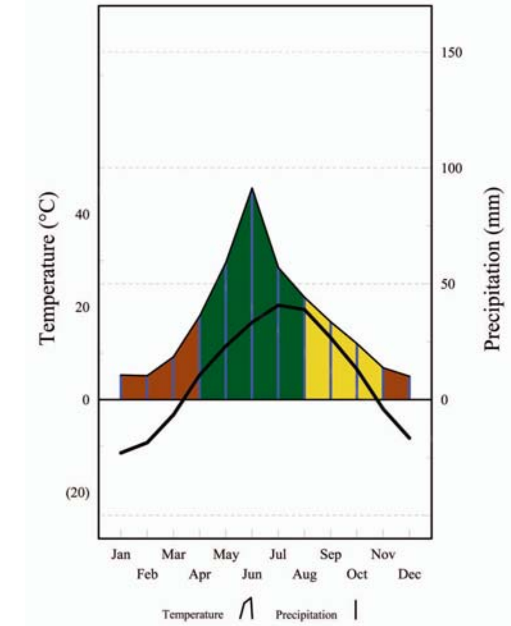


1892-1919 28 Years		
Months with water deficiency	36.3%	2.2 month/yr
Years with no water deficiency	3.6%	1 yr in 28 yrs
Dry growing seasons	28.6%	1 yr in 3.5 yrs
Wet growing seasons	14.3%	1 yr in 7 yrs
Normal growing seasons	57.1%	1 yr in 1.8 yrs

1920-1949 30 Years		
Months with water deficiency	33.1%	2.0 month/yr
Years with no water deficiency	6.1%	1 yr in 15 yrs
Dry growing seasons	16.7%	1 yr in 6 yrs
Wet growing seasons	10.0%	1 yr in 10 yrs
Normal growing seasons	73.3%	1 yr in 1.4 yrs

1950-1979 30 Years		
Months with water deficiency	31.1%	1.9 month/yr
Years with no water deficiency	3.3%	1 yr in 30 yrs
Dry growing seasons	10.0%	1 yr in 10 yrs
Wet growing seasons	26.7%	1 yr in 3.8 yrs
Normal growing seasons	63.3%	1 yr in 1.6 yrs

1980-2005 26 Years		
Months with water deficiency	30.1%	1.8 month/yr
Years with no water deficiency	11.5%	1 yr in 8.7 yrs
Dry growing seasons	7.7%	1 yr in 13 yrs
Wet growing seasons	19.2%	1 yr in 5.2 yrs
Normal growing seasons	73.1%	1 yr in 1.4 yrs



Ombrothermic diagram (1892-2005) at Dickinson, North Dakota

Percent frequency of water deficiency occurring during months of the growing season

April	May	June	July	August	September	October
16.7%	14.0%	9.6%	37.7%	51.8%	50.9%	47.4%

Water deficiency conditions occur during 32.68% of growing season months, mid April to mid October. On the average, 2.0 months during every 6.0-month growing season have water deficiency.

Ombrothermic Graph Technique

This method graphs the mean monthly temperature (°C) and monthly precipitation (mm) on the same axis, with the scale of the precipitation data at twice that of the temperature data. The temperature and precipitation data are plotted against an axis of time. The resulting ombrothermic diagram shows general monthly trends and identifies months with water deficiency conditions, unfavorable periods during which perennial plants experience water stress. Water deficiency exists during months when the precipitation data bar drops below the temperature data curve. Plants are under temperature stress when the temperature curve drops below the freezing mark (0°C).

Management practices that reduce the impact of water stress

- Improve soil structure and water infiltration by stimulating soil organism activity in the rhizosphere.
- Improve soil water holding capacity by stimulating grass root growth.
- Reduce evaporation of soil water by maintaining soil litter cover.
- Reduce soil temperature by maintaining grass leaf canopy cover.
- Improve plant density by stimulating vegetative reproduction of axillary crown buds.
- Maintain plant health by using a biologically effective grazing management strategy like the twice-over rotation system.

Literature Cited

Emberger, C., H. Gaussen, M. Kassas, and A. dePhilippis. 1963. Bioclimatic map of the Mediterranean Zone, explanatory notes. UNESCO-FAO. Paris. 58p.