SOUTH CAROLINA IRRIGATION GUIDE

CHAPTER 2. SOILS

Contents

Figures

Tables

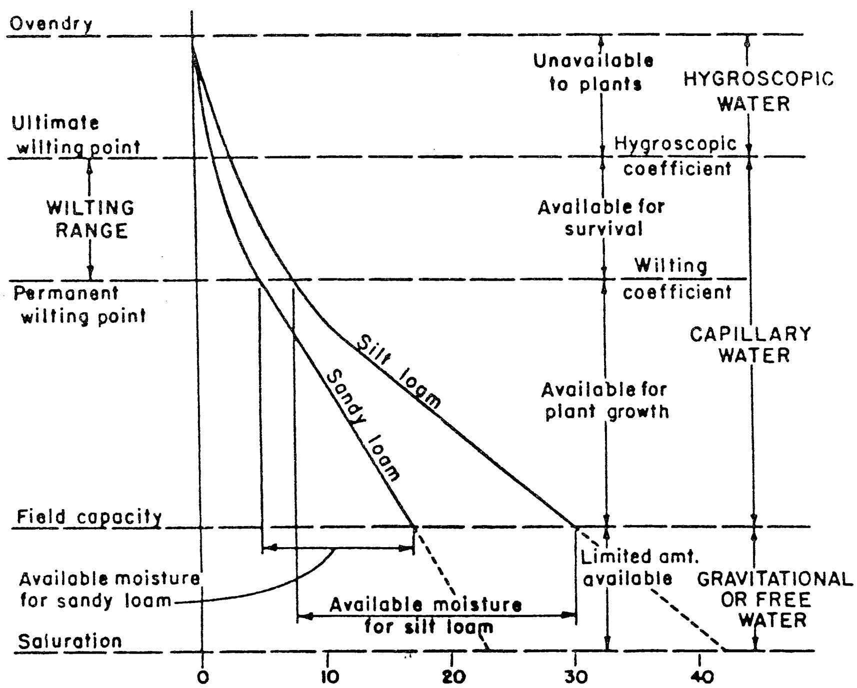
CHAPTER 2. SOILS

GENERAL

A knowledge of soil properties is necessary for the efficient use of water for crop production. Soil survey maps and special request maps are available to all field offices. The different kinds of soils and their distribution are identified on these maps, and important physical and chemical characteristics of each kind of soil are recorded in the SCS technical guides. Some characteristics of soils important to understanding soil-moisture plant relationships are discussed in this guide. They include permeability, intake rate, slope, depth to water table, and texture. All of these help determine the potential available water capacity. Also, organic matter content and bulk density help determine available water capacity.

AVAILABLE WATER CAPACITY AND SOIL MOISTURE TENSION

The available water capacity (AWC) of a soil is a measure of its capacity to make water available for plant growth. The AWC is the amount of water held between field capacity (FC) and the permanent wilting point (WP) as shown in Figure 2-1. AWC is expressed as the water retained between 1/3 bar and 15 bars tension for fine to medium textured soils and between 1/10 bar and 15 bars for moderately coarse to very coarse textured soils.



Soil Moisture Content (Percent by Dry Weight)

Figure 2-1. Soil Moisture Content - Kinds of Water in the Soil

There are a number of methods used to determine when to irrigate. One method is based on soil-moisture tension. The relationship between this concept and AWC is shown by the moisture release curves for three soils, Figure 2-2. In this figure moisture content is expressed as a percentage of AWC rather than as percentage by weight. FC is 100 percent of AWC and the WP (15 bars) is 0 percent of AWC. Tension at any moisture level is different for the three soils. At the 50 percent level, for example, moisture tension for the clay is about 4.3 bars (atmospheres); for the loam, 2.0 bars; and for the sand 0.6 bars. (These values shown for comparison only and do not represent any particular soil.)

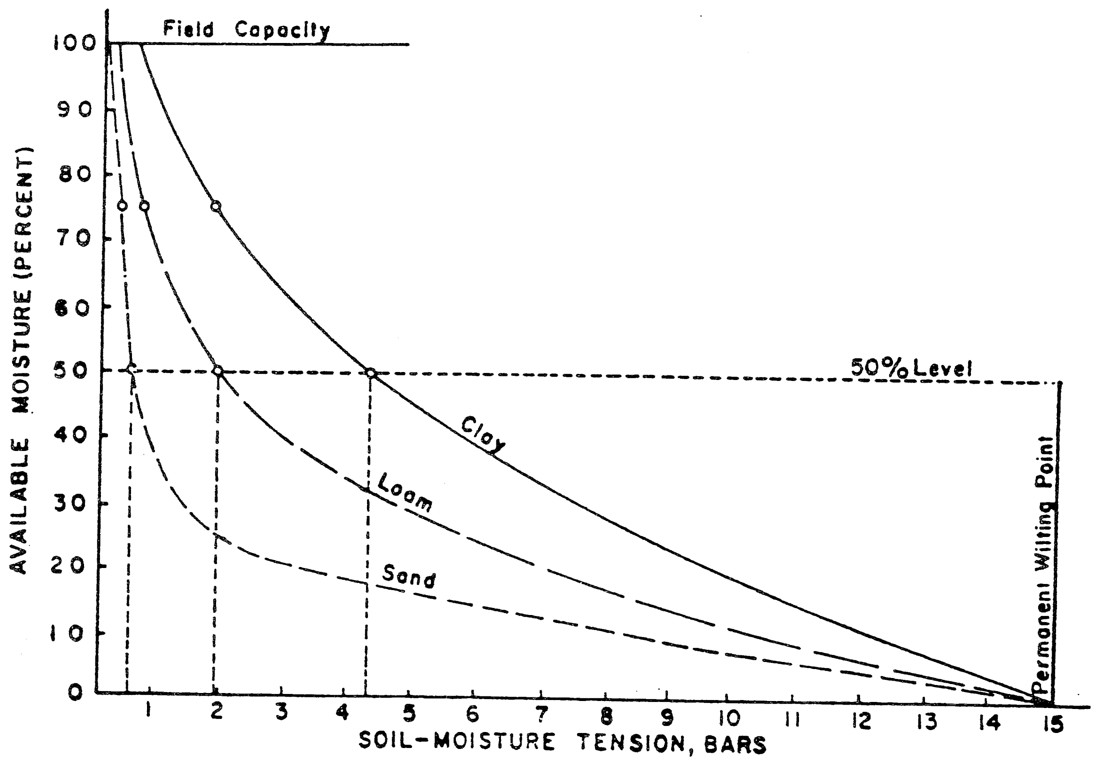


Figure 2-2. Moisture Release Curves for Three Soils

Moisture is more readily available to plants at low soil moisture tension (near field capacity). Since tension values are so different in the three soils shown in Figure 2-2, it is possible that crop response would be different if the soils were irrigated when tension reaches a given value rather than when available moisture is depleted to a given value. See Chapter 3 (Crops) and Chapter 11 (Water Management) for information on when to irrigate.

The SCS Field Office Technical Guide, Section II-B, Soils Descriptions, or either a published soil survey can be used to obtain the AWC for South Carolina soils. For example, the available water capacity of the top 18 inches in a Faceville soil in Aiken County is:

Sandy loam	0"- 6",	0.075 in./in. x 6 in.	= 0.45 in.
Sandy clay	6"-18",	0.150 in./in. x 12 in.	= 1.80 in.
Total AWC for 18 in. depth			= 2.25 in.

Water retention values for various soil water tension levels are shown in Table 2-1 for Southern Piedmont and Coastal Plain soil texture groupings. From this table, water retention for a Faceville soil (coastal plain soil) in Aiken County at the indicated soil moisture tensions may be estimated as follows:

Depth	Texture	.10 bar tension	0.5 bar tension	Difference
0- 6"	Sandy loam	0.20 inches/inch	0.15 inches/inch	0.05 in/in
6-18"	Sandy clay	0.27 inches/inch	0.23 inches/inch	0.04 in/in

The water retention capacity in the 18 inch depth for this range of tension is:

6(0.05) + 12(.04) = .78"

The 2.25 inches of AWC represents the differences in the amount of water held between about 0.1 bar and 15 bar tension whereas the 0.78 inches represents the differences in water retention between 0.1 bar and 0.5 bar (the latter being the range measurable by a tensiometer).

Table 2-1. Water Retention Versus Tension for soil-texture groupings 1/

Southern Piedmont Soils

Layer	Soil Texture	Water retention, inch/inch, at tension of- 0.03 bar	0.06 bar	0.25 bar	0.50 bar	0.75 bar	1.0 bar
Surface...	Loamy sand or coarse sandy loam.	0.22	0.17	0.125	0.11	0.105	0.10
Subsoil...	Sandy clay loam, clay loam, or clay.	.36	.34	.32	.30	.....	.29
Surface...	Sandy loam.	.28	.23	.17	.165	.155	.15
Subsoil...	Sand, clay loam, clay loam, or clay.	.36	.34	.32	.30	.....	.29
Surface...	Loam to clay loam.	.35	.34	.32	.31	.30	.295
Subsoil...	Sandy clay loam, clay loam, or clay.	.36	.34	.32	.30	.....	.29

Coastal Plain Soils

Layer	Soil Texture	Water retention, inch/inch, at tension of- 0.025 bar	0.05 bar	0.10 bar	0.25 bar	0.50 bar	1.0 bar
Surface...	Sand and loamy sand.	0.29	0.20	0.13	0.10	0.08	0.07
Subsoil...	Sand and loamy sand.	.29	.20	.13	.10	.08	.07
Surface...	Sand and loamy sand.	.29	.20	.13	.10	.08	.07
Subsoil...	Sandy loam and fine sandy loam.	.31	.26	.20	.17	.15	.13
Surface...	Sand and loamy sand.	.29	.20	.13	.10	.08	.07
Subsoil...	Sandy clay loam and sandy clay.	....	.30	.27	.25	.23	.22
Surface...	Loamy fine sand.	.29	.25	.18	.13	.11	.09
Subsoil...	Sandy clay loam and sandy clay.	....	.30	.27	.25	.23	.22
Surface...	Loamy fine sand.	.29	.25	.18	.13	.11	.09
Subsoil...	Sandy loam and fine sandy loam.	.31	.26	.20	.17	.15	.13
Surface...	Sandy loam and fine sandy loam.	.31	.26	.20	.17	.15	.13
Subsoil...	Sandy clay loam and sandy clay.	....	.30	.27	.25	.23	.22

1/ From Irrigation of Crops in Southeast US ARM 5-9/May 1980 p. 18 and 19.

TEXTURE

Texture is shown for all map units in the SCS Technical Guide, Section II-G, Engineering Interpretations. The following abbreviations are used:

Sand	S
Coarse sand	COS
Fine sand	FS
Loamy coarse sand	LCOS
Loamy sand	LS
Loamy fine sand	LFS
Loamy very fine sand	LVFS
Coarse sandy loam	COSL
Sandy loam	SL
Fine sandy loam	FSL
Very fine sandy loam	VFSL
Loam	L
Silt loam	SIL
Clay loam	CL
Sandy clay loam	SCL
Silty clay loam	SICL
Silty clay	SIC
Sandy clay	SC
Clay	C
Muck or peat	MK or PT

Additional textural modifiers are:

Channery	CN
Gravelly	GR
Shaley	SH

As a guide and quick reference for general planning, estimated available water capacity for selected textures is given in Table 2-2.

Table 2-2. Generalized Available Water Capacity for Selected Textures

Texture	Average AWC (in/in)	Suggested Range in AWC (in/in)
Sand	0.05	0.03 - 0.07
Fine sand	0.06	0.03 - 0.09
Loamy sand	0.08	0.06 - 0.10
Loamy fine sand	0.10	0.07 - 0.13
Sandy loam	0.12	0.09 - 0.15
Fine sandy loam	0.13	0.10 - 0.16
Silt loam	0.18	0.14 - 0.22
Sandy clay loam	0.16	0.13 - 0.19
Clay loam	0.17	0.14 - 0.20
Silty clay loam	0.18	0.14 - 0.22
Sandy clay	0.16	0.13 - 0.19
Clay	0.17	0.14 - 0.20

IRRIGATION RESTRICTIVE FEATURES

Table 2-3 contains a listing of features affecting irrigation. For information on features affecting irrigation for a particular map unit, see the SCS Technical Guide, Section II.

Table 2-3. Features Affecting Irrigation

	PROPERTY	LIMITS	RESTRICTIVE FEATURES
1.	Fraction >3 in (wt pct) 1/	>25	Large stones
2.	Depth to high water table (ft)	<3 +	Wetness Ponding
3.	Available water capacity 1/ (in/in)	<0.10	Droughty
4.	USDA texture (surface layer)	COS, FS, VFS, LCOS, LS, LFS, LVFS	Fast intake
5.	USDA texture (surface layer)	SIC, C, SC	Slow intake
6.	Wind erodibility group	1, 2, 3	Soil blowing
7.	Permeability (in/hr) (0-60")	<0.2	Percs slowly
8.	Depth to bedrock (in)	<40	Depth to rock
9.	Depth to cemented pan (in)	<40	Cemented pan
10.	Fragipan (great group)	All fragi	Rooting depth
11.	Bulk density (g/cm^3) (0-40")	>1.7	Rooting depth
12.	Slope (pct)	>3	Slope
13.	Erosion factor (K) (surface layer)	>.35	Erodes easily
14.	Flooding	Common	Floods
15.	Sodium absorption ratio (great group)	>12 (Natric, Halic)	Excess sodium
16.	Salinity (mmhos/cm) (0-40")	>4	Excess salt
17.	Soil reaction (pH)	<3.6	Too acid

1/ Weighted average to 40 inches.

USDA LAND CAPABILITY CLASSIFICATION SYSTEM

The USDA Land Capability Classification System is a general guide in selection of sites suitable for irrigation systems. The capability groupings are based on the limitations of soils, the risk of damage, and the way soils respond to treatment when used for cropland.

Soils are grouped into eight capability classes from I through VIII. Class I soils have the fewest limitations, widest range of uses and the least risk of damage when row cropped continuously. Soils in higher classes have progressively greater natural limitations.

Within each class of II to VIII, there can be as many as three subclasses designated by the letters "e," "w," or "s." Table 2-4 defines the limitations of each class.

TABLE 2-4. LAND USE CAPABILITY SUBCLASSES

Subclass	Major Limitation
e	Risk of erosion unless a close-growing plant cover is maintained
w	Water in or on the soil interferes with plant growth or cultivation; artificial drainage may eliminate or reduce wetness problems
s	Soils are limited by shallowness, droughty or stony conditions

The subclasses are further divided into capability units. The capability units are similar groups of soils that are suited to the same crops and forage plants. These soils require similar management and have similar yields. Capability units are available through county Soil Conservation Service offices (see S. C. Technical Note Soils-3).

Land used for irrigation and continuous row crops should fall in Classes I - III for best results. Erosion control measures are needed on Class II and Class III with a subclass of "e." Planning and installation for erosion control practices should be done prior to installation of an irrigation system. Wetness problems can be expected on soils with a subclass of "w." Surface and/or subsurface drainage may partially correct wetness problems. Droughty conditions occur on many soils with a subclass of "s." Irrigation will reduce this limitation in many cases. Low fertility, excessive leaching, and erosion problems may also occur on these soils.

Soils with marginal or very little potential for crop production fall in Classes IV-VIII. These soils have severe natural limitations and some may produce low yields under the best management. Irrigation on some Class IV-s land has been successful in the Coastal Plain. This land requires better than average management and the cost per unit of production is generally higher. A careful site by site evaluation is needed before irrigating Class IV-s land.

Land in Classes IV through VIII is normally better suited for hayland, pastureland, woodland, wildlife land or other uses where a permanent cover can be maintained.

The USDA Land Capability Classification System is a useful tool for general planning. Site specific information is necessary to plan the best irrigation system.

EROSION CONTROL

Soil and water conservation needs for an irrigated area may influence the design of an irrigation system. Table 2-5 lists conservation practices that may have the most impact. Other practices including waterways, field ditches, water and sediment control basins, field borders, and filter strips should be considered as appropriate.

TABLE 2-5

Conservation Practice	Major Benefits	Limitations
Contour Farming	-reduction of runoff from low to medium intensity storms -more infiltration of rain and irrigation water -significant reduction of soil loss at minimum cost	-not effective on 3-8% slopes -minimum 4" bed needed for effective water control -row alignment may be difficult to follow on steep or nonuniform slopes -intensive rain or irrigation rates can cause row breakovers and gully erosion
Crop Residue Use	-reduction of wind and water erosion when residue is left on soil surface -increased tilth due to increased organic matter -increases water infiltration, reduce runoff and microorganism activity -reduce evaporation from soil surface	-may require minimum tillage equipment -may not be compatible with all cropping rotations

TABLE 2-5 (Continued)

Conservation Practice	Major Benefits	Limitations
Contour Stripcropping	-similar benefits to contour farming -reduce sediment, reduce runoff, and increase infiltration	-difference crops under the same irrigation system may have different water needs -chemigation generally not feasible -row alignment may not fit large equipment -grassed waterways and pipe outlets may be needed for water control
Terrace Systems	-reduction of runoff which improves water conservation -increase in infiltration -reduction of field sediment loss -enduring conservation practice	-expensive -requires grassed waterways or pipe outlets for water disposal -layout may not fit large equipment -requires annual maintenance
Conservation Tillage	-reduces runoff and sediment loss -increases infiltration and reduces crusting problems -reduces evaporative losses from soil surface -allows more versatile double-cropping systems -effective in wind erosion control	-usually requires specialized equipment -not compatible with all cropping systems -requires expert management and weed control emphasis
Furrow Diking	-reduces ponding in low areas -reduction of runoff and sediment losses -reduced erosion -reduction of wind erosion -can reduce pumping cost due to use of low pressure systems -increase in infiltration	-requires specialized equipment -dikes may interfere with cultural or harvesting operations unless they are plowed out -limited mostly to slopes less than 2 percent or to contouring operations

MAXIMUM IRRIGATION APPLICATION RATES

Sprinkler irrigation application rates and amount should be related to the temporary surface storage available and to a soil's capacity to absorb irrigation water from the surface, and move it into and through the soil profile.

The amount of moisture already in the soil greatly influences the rate at which water enters the soil. The soil takes in and absorbs irrigation water rapidly when water is first applied to the field surface. As the irrigation application continues, the surface soil gradually becomes saturated and the intake rate decreases until it reaches a nearly constant value. Any excess water accumulates for a period of time in soil pores in the surface layer and in surface depressions. When this temporary storage is filled to capacity, runoff begins. Proper management can increase retention time by increasing surface storage capacity on or near the soil surface. A greater amount of excess water is stored, and more time is allowed for water to enter the soil profile. This can be accomplished by several practices including surface residue cover, tillage-induced surface roughness (such as furrow diking), and contour or cross-slope farming. These measures also help to improve infiltration rates and to slow velocity of surface runoff.

The intake of any soil is limited by any restriction to the flow of water into or through the soil profile. The soil layer within the soil water control zone with the lowest transmission rate, either at the surface or directly below it, usually has major effect upon the intake rate. Important general factors that influence intake rates and thus application rates are the physical properties of the soil and, in sprinkler irrigation, the plant cover.

Irrigation application rates in Table 2-6 are to be used as a guide in arriving at maximum application rates for sprinkler applications in South Carolina. The values given are estimates based upon data published in S. C. Agricultural Experiment Station Technical Bulletin 1022, recommendations from NEH-15, Chapter 11, and results and observations obtained from recent irrigation evaluation tests made in South Carolina. Higher application rates may be used with smaller applications due to the higher initial intake rate and surface storage, etc. For trickle systems, see Chapter 7 of the SCS National Engineering Handbook, Section 15 (copy maintained by SCS Engineers), until such time that trickle information is added to this guide.

Table 2-6. Maximum Sprinkler Irrigation Application Rates (In/Hr) For Row Crops 1/

Group No.	Soil Texture in Soil-Water Control Zone	Land Slope (%)	Net Application Depth 0.5"	1.0"	1.5"	2.0"
1	Sand	under 2 2-5 over 5	2/ 2/ 2/	2/ 2/ 3.0	3.0 2.5 2.0	2.0 1.5 1.0
2	Sand and loamy sand	under 2 2-5 over 5	2/ 2/ 3.0	3.0 2.5 2.0	2.0 1.5 1.0	1.5 1.0 .8
3	Sand and loamy sand over sandy loam or fine sandy loam	under 2 2-5 over 5	2/ 3.0 2.5	2.0 1.5 1.0	1.5 1.0 .8	1.0 .8 .6
4	Loamy fine sand over sandy loam or fine sandy loam	under 2 2-5 over 5	3.0 2.5 2.0	1.5 1.2 .8	1.0 .8 .5	.7 .5 .4
5	Loamy fine sand, or loamy sand over sandy clay loam or sandy clay	under 2 2-5 over 5	2.0 1.5 1.0	1.2 .8 .6	.8 .5 .4	.6 .4 .3
6	Sandy loam, fine sandy loam, or loam over sandy clay loam or sandy clay	under 2 2-5 over 5	1.5 1.0 .8	1.0 .6 .5	.6 .5 .4	.5 .4 .3
7	Sandy clay loam, loam, silt, or clay loam over silty clay, clay loam, or clay	under 2 2-5 over 5	1.2 .8 .5	.6 .5 .4	.5 .4 .3	.4 .3 .2

1/ Use of some cultural practices such as bedding and contouring, row diking, and possibly others may warrant that application rate not be a limiting factor in design. These practices shall be documented to support planning and design.

For grasses or minimum tillage crops with approximately 50% or more ground cover, tabular values may be increased 25%.

For some crops and gun sprinklers, factors other than soil texture, slope, and application depth may dictate that application rates be less than shown. These include but are not limited to crop type, lack of ground cover, droplet impact, and hydrologic condition of the soil. As a guide use approximately 0.8 inch/hour as the maximum allowable gun sprinkler application rate. Adjust lesser values downward as experience dictates.

2/ For soils with these textures, slopes, and application depths, soil intake rates are usually not the limiting factor in system design. Other factors including crop type and droplet impact should be considered to arrive at an application rate. For interpolation between other values in this table, a value of 4.0 inches per hour may be used except for gun sprinklers as noted above.