

# TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

TN - AGRONOMY - 43

JUNE 1987

## CLIMATIC, SOIL, AND WATER REQUIREMENTS OF CROPS

Attached are West NTC Ecological Sciences Technical Note W-38 and Supplement 1 that were prepared by Travis Stevenson, conservation agronomist at the WNTC.

Growth requirements for the major crops grown in the West are presented in five tables. This is a comprehensive tabulation of available data and will be very useful for applying both the conservation cropping sequence and irrigation water management practices.

---

Prepared by Walt Bunter, State Agronomist, Ecological Sciences Staff, Soil Conservation Service, Davis, California.

CA-43-1

WEST NTC ECOLOGICAL SCIENCES TECHNICAL NOTE W-38

SUBJECT: ECS - Agronomy - Tables: Climatic, Soil and Water Requirements for Crops - Resistance of Crops to Frost in Different Developmental Phases - Optimum Germination Temperatures for Major Crop Seeds - Typical Rooting Depths for Major Crops - Converting Temperatures: Celsius (C) to Fahrenheit (F).

Purpose.

This technical note transmits information about growth requirements and data needed in working with the major crops grown in the West.

Background.

Information for alternative cropping systems is needed in providing technical assistance to landowners. Data on growth requirements for the major crops grown in the West has been summarized and is being distributed for field use. This data and other information in the published soil surveys will assist in presenting alternative cropping systems.

---

Prepared by Travis Stevenson, Conservation Agronomist, WNTC, Portland, OR

Table 1a. CLIMATIC, SOIL AND WATER REQUIREMENTS FOR CROPS

CROP (1)	TOTAL GROWING PERIOD (DAYS) (2)	TEMPERATURE REQUIREMENTS FOR GROWTH, F OPT. 1/(RANGE) (3)	DAYLIGHT REQUIREMENTS FOR FLOWERING (4)	SPECIFIC CLIMATIC CONSTRAINTS AND REQUIREMENTS (5)	SOIL REQUIREMENTS (6)
Alfalfa	100-365	75-79 (50-86)	Day neutral	Sensitive to frost; cutting interval related to temp.; requires low RH in warm climates	Deep, medium-textured, well-drained, pH 6.5-7.5
Bean	Fresh: 60-90 Dry : 90-120	59-68 (50-81)	Short day/ day neutral	Sensitive to frost; excessive rain, hot weather	Deep, friable soil, well-drained and aerated; opt. pH 5.5-6.0
Cabbage	100-150	59-68 (50-75)	Long day	Short periods of frost (21-14 F) are not harmful; opt. RH 60-90	Well drained; opt. pH 6-6.5
Citrus	240-365	73-86 (55-95)	Day neutral	Sensitive to frost (dormant trees less), strong wind, high humidity; cool winter or short dry period preferred	Deep well-aerated, light to medium-textured soils, free from stagnant water; pH 5-8
Corn	150-180	75-86 (59-95)	Day neutral/ short day	Sensitive to frost; for germination temp. >50 F; cool temp. causes problem for ripening	Well drained and aerated soils with deep water table and without waterlogging; opt. pH 5.0-7.0
Cotton	150-180	68-86 (61-95)	Short day/ day neutral	Sensitive to frost; strong or cold winds; temp. req. for boll development: 81-90 F (64-100); dry ripening period required	Deep, medium to heavy-textured soils; pH 5.5-8.0 with opt. pH 7.0-8.0
Grape	180-270	68-77 (59-86)		Resistant to frost during dormancy (down to 0 F) but sensitive during growth; long, warm to hot, dry summer and cool winter preferred/required	Well-drained, light soils are preferred
Olive	210-300	68-77 (59-95)		Sensitive to frost (dormant trees less); low winter temp. required (<50 F) for flower bud initiation	Deep, well-drained soils free from waterlogging
Onion	100-140 (+30-35 in nursery)	59-68 (50-77)	Long day/ day neutral	Tolerant to frost; low temp. (<57-61 F) required for flower initiation; no extreme temp. or excessive rain	Medium-textured soil; pH 6.0-7.0
Pea	Fresh: 65-100 dry : 85-120	59-64 (50-73)	Day neutral	Slight frost tolerance when young	Well-drained and aerated soils; pH 5.5-6.5

continued ==

Table 1a (page 2)

CROP (1)	TOTAL GROWING PERIOD (DAYS) (2)	TEMPERATURE REQUIREMENTS FOR GROWTH, F OPT. 1/(RANGE) (3)	DAYLIGHT REQUIREMENTS FOR FLOWERING (4)	SPECIFIC CLIMATIC CONSTRAINTS AND REQUIREMENTS (5)	SOIL REQUIREMENTS (6)
Peanut	90-140	22-28 (18-33)	Day neutral	Sensitive to frost; for germination temp. >50 F	Well-drained, friable, medium-textured soil with loose top soil; pH 5.5-7.0
Pepper	120-150	64-73 (59-81)	Short day/ day neutral	Sensitive to frost	Light to medium-textured soils; pH 5.5-7.0
Pineapple	365	72-79 (64-86)	Short day	Sensitive to frost; requires high RH; quality affected by temp.	Sandy loam with low lime content; pH 4.5-6.5
Potato	100-150	59-68 (50-77)	Long day/ day neutral	Sensitive to frost; night temp. <59 F required for good tuber initiation	Well-drained, aerated and porous soils; pH 5.0-6.0
Rice	90-150	72-86 (64-95)	Short day/ day neutral	Sensitive to frost; cool temp. causes head sterility; small difference in day and night temp. is preferred	Heavy soils preferred for percolation losses, high tolerance to O <sub>2</sub> deficit; pH 5.5-6.0
Safflower	Spring: 120-160 Autumn: 200-230	Early growth 59-68 later growth 68-86 (50-95)		Tolerant to frost; cool temp. req. for good establishment and early growth	Fairly deep, well-drained soils, preferably medium-textured; pH 6.0-8.0
Sorghum	100-140+	74-86 (59-95)	Short day/ day neutral	Sensitive to frost; for germination temp. >50 F; cool temp. causes head sterility	Light to medium/heavy soils relatively tolerant to periodic waterlogging, pH 6.0-8.0
Soybean	100-130	68-77 (64-86)	Short day/ day neutral	Sensitive to frost; for some var. temp. >75 F required for flowering	Wide range of soil except for sandy well-drained; pH 6.0-6.5
Sugarbeet		64-72 (50-86)	Long day	Tolerant to light frost; toward harvest mean daily temp. <50 F for, high sugar yield	Medium to slightly heavy-textured soils, friable and well-drained; pH 6.0-7.0
Sugarcane	270-365	72-86 (59-95)	Short day/ day neutral	Sensitive to frost; during ripening cool (50-68 F), dry sunny weather is required	Deep, well aerated with ground water deeper than 60 in. but rel. tolerant to periodic high watertables and O <sub>2</sub> deficit; pH 5.0-8.5; opt. pH 6.5
Sunflower	90-130	64-77 (59-86)	Short day/ day neutral	Sensitive to frost	Fairly deep soils; pH 6.0-7.5

continued ==

Table 1a (page 3)

CROP (1)	TOTAL GROWING PERIOD (DAYS) (2)	TEMPERATURE REQUIREMENTS FOR GROWTH, F OPT. 1/(RANGE) (3)	DAYLIGHT REQUIREMENTS FOR FLOWERING (4)	SPECIFIC CLIMATIC CONSTRAINTS AND REQUIREMENTS (5)	SOIL REQUIREMENTS (6)
Tomato	90-140 (+25-35 in nursery)	64-77 (59-82)	Day neutral	Sensitive to frost	Quality of leaf depends on soil texture; pH 5.0-7.0
Watermelon	80-110	72-86 (64-95)	Day neutral	Sensitive to frost	Sandy loam is preferred; pH 5.8- 7.2
Wheat	Spring 100-130 Winter 180-250	59-68 (50-77)	Day neutral long day	Spring wheat sensitive to frost Winter wheat: resistant to frost during dormancy (>64 F), sensitive during post-dormancy period; re- quires a cold period for flowering during early growth. For both, dry period required for ripening	Medium-textured soils are preferred; relatively tolerant to high watertables; pH 6.0-8.0

## Notes:

RH = Relative Humidity

OPT. = Optimum

Table 2a. CLIMATIC, SOIL AND WATER REQUIREMENTS FOR CROPS

CROP (1)	SENSITIVITY TO SALINITY (2)	FERTILIZER REQUIREMENTS LBS/AC/GROWING PERIOD			WATER REQUIRE- MENTS IN/ GROW PER. (4)	SENSITIVITY TO WATER SUPPLY (5)	WATER UTILIZATION EFFICIENCY FOR HARVESTED YIELD, LBS/AC.FT. (%MOISTURE) (6)
		N	P	K			
Alfalfa	Moderately sensitive	0-36	49-58	67-89	32-63	low to medium-high	4095-10980 hay: (10-15%)
Bean	Sensitive	18-36	36-54	45-107	12-20	Medium-high	Lush: 4095-5225 (80-90%) Dry : 828-1612 (10%)
Cabbage	Moderately sensitive	89-134	45-58	89-116	15-19	Medium-low	32625-54365 head (90-95%)
Citrus	Sensitive	89-198	31-40	45-143	35-47	Low to medium/high	5445-13590 fruit (85%, lime: 70%)
Corn	Moderately sensitive	89-198	45-71	54-89	20-31	High	2178-4356 grain (10-13%)
Cotton	Tolerant	89-161	18-54	45-71	28-51	Medium-low	1090-1612 seed cotton (10%)
Grape	Moderately sensitive	89-143	36-54	143-205	20-47	Medium-low	5445-10890 fruit (80%)
Olive	Moderately tolerant	198-223	49-62	143-187	24-31	Low	4095-5445 fruit (30%)
Onion	Sensitive	54-89	22-40	40-71	14-22	Medium-high	21780-27180 bulb (85-90%)
Pea	Sensitive	18-36	36-54	71-143	14-20	Medium-high	Fresh: 1350-1916 shelled (70-80%) Dry : 392-566 shelled (10%)

=====continued==

Table 2a (page 2)

CROP (1)	SENSITIVITY TO SALINITY (2)	FERTILIZER REQUIREMENTS LBS/AC/GROWING PERIOD			WATER REQUIRE- MENTS IN/ GROW PER. (4)	SENSITIVITY TO WATER SUPPLY (5)	WATER UTILIZATION EFFICIENCY FOR HARVESTED YIELD, LBS/AC.FT. (%MOISTURE) (6)
		N	P	K			
Peanut	Moderately sensitive	9-18	13-26	22-36	20-28	Low	1612-2178 unshelled dry nut (15%)
Pepper	Moderately sensitive	89-152	22-45	45-89	24-35	Medium-high	4095-8145 fresh fruit (90%)
Pineapple		205-268	40-58	98-196	28-39	Low	Plant crop: 13590-27180 ratoon : 21780-32626 fruit (85%)
Potato	Moderately sensitive	71-107	45-71	112-143	20-28	Medium-high	10890-19035 fresh tuber (70-75%)
Rice	Moderately sensitive	89-134	18-36	71-107	14-28	High	1916-3005 paddy (15-20%)
Safflower	Moderately tolerant	54-98	13-27	22-36	24-47	Low	566-1350 seed (8-10%)
Sorghum	Moderately tolerant	89-161	18-40	31-71	18-26	Medium-low	1611-2700 grain (12-15%)
Soybean	Moderately tolerant	9-18	13-27	22-58	18-28	Medium-low	1090-1915 grain (6-10%)
Sugarbeet	Tolerant	134	45-62	89-143	22-30	Low to medium-low	Beet: 16291-24480 (80%) Sugar: 2439-3790 (0%)
Sugarcane	Moderately sensitive	89-178	18-80	112-143	59-68	High	Cane : 13590-21780 (80%) Sugar: 1611-2787 (0%)
Sunflower	Moderately tolerant	45-89	18-40	54-112	24-39	Medium-low	828-1350 seed (6-10%)

=====continued==

Table 2a (page 3)

CROP (1)	SENSITIVITY TO SALINITY (2)	FERTILIZER REQUIREMENTS LBS/AC/GROWING PERIOD			WATER REQUIRE- MENTS IN/ GROW PER. (4)	SENSITIVITY TO WATER SUPPLY (5)	WATER UTILIZATION EFFICIENCY FOR HARVESTED YIELD, LBS/AC.FT. (%MOISTURE) (6)
		N	P	K			
Tomato	Moderately sensitive	89-134	: 58-98	: 143-214	16-24	Medium-low	27181-32626 fresh fruit (80-90%)
Watermelon	Moderately sensitive	71-89	: 22-54	: 31-71	16-24	Medium-high	13590-32626 fruit (90%)
Wheat	Moderately tolerant	89-134	: 31-40	: 22-45	18-26	Medium-high	2180-2700 grain (12%)

RESISTANCE OF CROPS TO FROST IN DIFFERENT DEVELOPMENTAL PHASES

Crop	Temperatures (F) harmful to plant in the phases of:		
	Germination	Flowering	Fruiting
<b>Highest resistance to frost:</b>			
Spring wheat	15-17	30-31	26-29
Oats	17-18	30-31	26-29
Barley	18-20	30-31	26-29
Peas	18-20	27-29	26-27
lentils	18-20	27-29	26-29
<b>Resistance to frost:</b>			
Beans	20-24	27-29	26-27
Sunflower	22-24	27-29	27-29
Safflower	22-26	27-29	26-27
Sugarbeet	20-22	27-29	-
Carrot	20-22	-	-
Turnip	20-22	-	-
<b>Low resistance to frost:</b>			
Corn	27-29	29-31	27-29
Millet	27-29	29-31	27-29
Sudangrass	27-29	29-31	27-29
Sorghum	27-29	29-31	27-29
Potatoes	27-29	29-31	29-31
<b>No resistance to frost:</b>			
Cotton	29-31	29-31	-
Watermelons	31-32	31-32	-
Rice	31-32	31-32	-
Sesame	31-32	31-32	-
Peanuts	31-32	-	-
Cucumbers	31-32	-	-
Tomatoes	31-32	31-32	-

OPTIMUM GERMINATION TEMPERATURES FOR MAJOR CROP SEEDS

Crop	Fahrenheit (F)			Days required for germination at different temperatures			
	Minimum	Optimum	Maximum	41 (F)	55 (F)	61 (F)	67 (F)
Red clover	34	86	99	7.5	3	1.75	1
Alfalfa	34	86	99	6	3.75	2.75	2
Peas	34-37	86	95	5	3	1.75	1.75
Wheat	39	77	86-90	6	3	2	1.75
Barley	39	68	82-86	6	3	2	1.75
Oats	39-41	77	86	7	3.75	2.75	2
Carrot	39-41	77	86	-	6.75	4.25	3.25
Sugarbeet	39-41	77	82-86	22	9	3.75	3.75
Lentils	39-41	86	97	6	3	2	1.75
Corn	46-45	90-95	104-111	-	11.25	3.25	3
Sorghum	46-50	90-95	104-111	-	11.25	4.75	4
Rice	50-54	86-90	97-100	-	-	-	-
Watermelon	54-59	95	104	-	-	15	17

TYPICAL ROOTING DEPTHS FOR MAJOR CROPS

Crop	Stage Of Plant Growth	RDm-In.
Alfalfa	1st. yr.	71 - 94
	Sev. yrs.	118 - 236
Asparagus	1st. yr	39 - 78
	Sev. yrs	118+
Barley	Annual	59 - 114
Beet	Annual	71 - 130
Broad bean	Annual	59 - 75
Bromegrass	1st.yr	39 - 59
	Sev. yrs	78+
Cabbage	Annual	59 - 94
Carrot	Annual	59 - 118
Cauliflower	Annual	35 - 59
Corn	Annual	71 - 118
Cotton	Annual	59 - 118
Cowpea	Annual	39 - 59
Cucumber	Annual	47 - 71
Eggplant	Annual	59 - 94
Flax	Annual	39 - 59
Garlic	Annual	24 - 39
Horseradish	Annual	118 - 177
Kidneybean	Annual	39 - 118
Kohlrabi	Annual	59 - 106
Leek	Annual	16 - 32
Lentils	Annual	34 - 28
Lettuce	Annual	59 - 98
Lima bean	Annual	39 - 78
Muskmelon	Annual	39 - 59
Oats	Annual	63 - 102
Okra	Annual	47 - 63
Onion	Annual	16 - 39
Parsley	Annual	35 - 59
Parsnip	Annual	78 - 118
Pea	Annual	39 - 94
Pepper	Annual	35 - 59
Potato	Annual	20 - 94
Pumpkin	Annual	59 - 83
Radish	Annual	55 - 94
Rape	Annual	78 - 118
Red clover	1st. yr.	55 - 71
	Sev. yrs.	78 - 118
Rhubarb	Sev. yrs.	78 - 118
Rutabaga	Annual	59 - 78
Rye	Annual	59 - 94
Sorghum	Annual	59 - 118

=====continued==

TYPICAL ROOTING DEPTHS FOR MAJOR CROPS (page 2)

Crop	Stage Of Plant Growth	RDm-In.
Soybean	Annual	59 - 98
Spinach	Annual	59 - 78
Squash	Annual	59 - 94
Strawberry		24 - 47
Sugarbeet	Annual	55 - 78
Sugarcane		78 - 236
Sunflower	Annual	59 - 118
Sweetclover	1st. yr.	59 - 94
	Sev. yrs.	118+
Sweet corn	Annual	59 - 71
Sweet potato	Annual	39 - 59
Swiss chard	Annual	71 - 94
Tomato	Annual	55 - 102
Turnip	Annual	59 - 78
Watermelon	Annual	39 - 59
Wheat	Annual	59 - 118

Notes: RDm=maximum rooting depths

The above rooting depths reflects root development over time independent of environmental conditions expected to interfere with normal growth characteristics- high bulk densities, high watertables, low fertility, low pH and other parameters. Root development on most soils are not modified to any great extent from their normal development, independent, soil characteristics normally do not inhibit root development it is manifested in slowed development.

CELSIUS (C) TO FAHRENHEIT (F)

Celsius	Fahrenheit	Celsius	Fahrenheit
-40	-40	8	46
-39	-38	9	48
-38	-36	10	50
-37	-35	11	52
-36	-33	12	54
-35	-31	13	55
-34	-29	14	57
-33	-27	15	59
-32	-26	16	61
-31	-24	17	63
-30	-22	18	64
-29	-20	19	66
-28	-18	20	68
-27	-17	21	70
-26	-15	22	72
-25	-13	23	73
-24	-11	24	75
-23	-9	25	77
-22	-8	26	79
-21	-6	27	81
-20	-4	28	82
-19	-2	29	84
-18	0	30	86
-17	1	31	88
-16	3	32	90
-15	5	33	91
-14	7	34	93
-13	9	35	95
-12	10	36	97
-11	12	37	99
-10	14	38	100
-9	16	39	102
-8	18	40	104
-7	19	41	106
-6	21	42	108
-5	23	43	109
-4	25	44	111
-3	27	45	113
-2	28	46	115
-1	30	47	117
0	32	48	118
1	34	49	120
2	36	50	122
3	37	51	124
4	39	52	126
5	41	53	127
6	43	54	129
7	45	55	131

Notes: Fahrenheit (F) = 9/5(C)+32

WEST NTC ECOLOGICAL SCIENCES TECHNICAL NOTE W-38 (Supplement 1)

SUBJECT: ECS - Agronomy - Followup Information to West NTC Ecological Sciences Technical Note W-38

Purpose.

To provide additional source information.

Background.

A limited supply of Technical Note W-38 is available by request from the WNTC. Several states have requested additional copies.

The following source data is supplied for your information.

<u>Tech. Note W-38</u>	<u>Data Source</u>
<u>Tables 1a and 2a, Pages 1-6</u> - Climatic, Soil, and Water Requirements for crops.	"Food and Agricultural Organization of the United Nations-Rome-1979." FAO Irrigation and Drainage Paper 33: Yield Response to Water. Table 2, p. 6-7.
<u>Page 7</u> - Resistance of Crops to Frost in Different Developmental Phases.	Rechcigl, Jr., Miloslav. "Resistance of Crops to Frost in Different Developmental Phases." Handbook of Agricultural Productivity - CRC Press. Vol. 1, Table 2, p. 15.
<u>Page 8</u> - Optimum Germination Germination Temperatures For Major Crop Seeds.	Rechcigl, Jr., Miloslav. "Cardinal Temperatures for Germination of Some Important Crop Seeds." Handbook of Agricultural Productivity. CRC Press. Vol. 1, Table 1, p. 14.
<u>Page 9 and 10</u> - Typical Rooting Depths For Major Crops	Borg, H. and D. W. Grimes. "Depth Development of Roots With Time: An Empirical Description." Transactions of ASEA. Vol. 29, Jan-Feb 1986, Table 1, p. 195.
<u>Page 11</u> - Celsius (C) to Fahrenheit (F)	I made these conversions using the AT&T Computer Spreadsheet and formula (F) = 9/5(C) + 32.

Please address any comments and requests to Travis Stevenson, WNTC.

---

Prepared by Travis Stevenson, Conservation Agronomist, WNTC, Portland, OR