CLIMATE, SOIL CHARACTERISTICS, AND IRRIGATION METHODS OF CALIFORNIA.

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THE RAINFALL.

The rainfall in California is exceedingly variable, ranging from a bountiful supply upon the high mountain summits to a small and uncertain quantity in the valleys. The greatest precipitation occurs in the northern portions of the State, about the heads of the Sacramento River, and the least in its extreme southern portions, where the average amount is about 3 inches annually.

It is to the snow and rain stored upon the mountain summits of California that the advanced and prosperous condition of its farmers and horticulturists is due, for while the State is annually visited in all its parts by a rainy season, the amount of precipitation, except in the extreme northern portions, is not sufficient for general crop production in the valleys, where the prime arable lands are to be found. Moreover, while these seasonal falls of rain are very variable, the years of least fall seem to occur at nearly regular intervals. The years of greatest fall do not occur with the same regularity. The following table of the seasonal rainfalls, from 1849 to 1890, from the observations taken at Sacramento and compiled by Sergeant Barwick, of the United States Signal Corps, very clearly shows these characteristics of California's rainy seasons:

TABLE I.—*Showing characteristics of seasonal rains in California.*

Rainy season of the year—	Total for season.	Rain for the month of—											
		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1849-50	36.00	------	------	------	------	------	------	------	------	0.25	1.50	2.25	12.50
1850-51	4.71	4.50	0.50	10.00	4.25	0.25	0	0	0	0	0	Spr.	Spr.
1851-52	17.98	.65	.35	1.88	1.14	.69	0	0	0	1.00	.18	2.14	7.07
1852-53	36.36	.58	.12	6.40	.19	.30	0	0	0	Spr.	0	6.00	13.40
1853-54	20.06	3.00	2.00	7.00	3.50	1.45	Spr.	Spr.	0	Spr.	Spr.	1.50	1.54
1854-55	18.62	3.25	8.50	3.25	1.50	.21	0.31	0	Spr.	Spr.	1.01	.65	1.15
1855-56	13.76	2.67	3.46	4.20	4.32	1.15	.01	0	0	Spr.	0	.75	2.00
1856-57	10.46	4.92	.69	1.40	2.13	1.84	.03	0	0	Spr.	.20	.65	2.40
1857-58	15.00	1.38	4.80	.68	Spr.	Spr.	.35	0	Spr.	0	.66	2.41	2.63
1858-59	16.03	2.44	2.46	2.88	1.21	.20	.10	0.01	Spr.	Spr.	3.01	.15	4.34
1859-60	22.09	.96	3.91	1.64	.98	1.04	0	0	0	.02	0	6.48	1.83
1860-61	16.10	2.31	.93	5.11	2.87	2.49	.02	.63	0	.06	.91	.18	4.28

TABLE I.—*Showing characteristics of seasonal rains in California*—Continued.

Rainy season of the year—	Total for season.	Rain for the month of—											
		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec
	Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1861–62	35.56	2.67	2.92	3.32	0.48	0.59	0.14	0.55	0	0	Spr.	2.17	8.64
1862–63	11.58	15.04	4.26	2.80	.82	1.81	.01	0	0.01	0	0.36	Spr.	2.33
1863–64	7.87	1.73	2.75	2.36	1.69	.36	0	0	0	Spr.	0	1.49	1.82
1864–65	22.51	1.08	.19	1.30	1.08	.74	.09	0	.08	Spr.	.12	6.72	7.87
1865–66	17.93	4.78	.71	.48	1.37	.46	0	Spr.	0	0.08	.48	2.43	.36
1866–67	25.30	7.70	2.01	2.02	.48	2.25	.10	.02	0	0	Spr.	2.43	9.51
1867–68	32.79	3.44	7.10	1.01	1.80	.01	0	0	0	.01	0	3.81	12.85
1868–69	16.64	6.04	3.15	4.35	2.31	.27	Spr.	0	0	0	0	.77	2.61
1869–70	13.57	4.79	3.63	2.94	1.24	.65	.01	0	0	Spr.	2.12	.85	1.96
1870–71	8.47	1.37	3.24	1.64	2.12	.27	Spr.	Spr.	Spr.	0	.02	.58	.97
1871–72	23.65	2.08	1.92	.69	1.45	.76	Spr.	0	0	Spr.	.21	1.22	10.59
1872–73	14.21	4.04	4.74	1.94	.61	.28	.02	0	0	Spr.	.22	1.93	5.39
1873–74	22.90	1.23	4.36	.55	.51	0	Spr.	.02	Spr.	0	.31	1.21	10.01
1874–75	17.70	5.20	1.86	3.05	.89	.37	Spr.	Spr.	0	.05	2.26	3.80	.44
1875–76	26.53	8.70	.55	.80	Spr.	Spr.	1.10	0	0	0	.44	6.20	5.52
1876–77	8.96	4.99	3.75	4.15	1.10	.15	0	.21	.02	Spr.	3.45	.30	
1877–78	24.86	2.77	1.04	.56	.19	.64	.01	Spr.	Spr.	0	.73	1.07	1.43
1878–79	17.85	9.26	8.04	3.09	1.07	.17	0	0	0	.29	.55	.51	.47
1879–80	26.47	3.18	3.88	4.88	2.66	1.30	.13	Spr.	Spr.	0	.88	2.05	3.41
1880–81	26.57	1.64	1.83	1.70	14.20	.76	0	Spr.	0	0	0	.05	11.81
1881–82	16.51	6.14	5.06	1.37	1.64	Spr.	.50	Spr.	0	.30	.55	1.88	3.27
1882–83	18.11	1.89	2.40	3.78	1.99	.35	.10	Spr.	0	.57	2.63	3.22	1.13
1883–84	24.78	2.23	1.11	3.70	.67	2.85	0	0	0	.90	.96	.61	.44
1884–85	16.58	3.43	4.46	8.14	4.32	.06	1.45	0	Spr.	.60	2.01	0	10.45
1885–86	32.27	2.16	.49	.08	.68	Spr.	.11	Spr.	0	.08	.02	11.34	5.76
1886–87	13.97	7.95	.29	2.68	4.08	.07	0	0	0	0	.68	.21	2.21
1887–88	11.56	1.12	6.28	.94	2.53	Spr.	0	0	Spr.	.02	0	.45	2.09
1888–89	19.95	4.81	.57	3.04	.10	.40	.08	Spr.	Spr.	.55	0	4.28	4.63
1889–90	--------	.15	.33	6.25	.26	3.25	.25	0	0	0	6.02	3.15	7.82
1890	--------	6.62	4.06	3.00	------	------	------	------	------	------	------	------	------
Average	19.58	3.78	2.80	2.95	1.86	.71	.12	.04	.003	.12	.80	2.14	4.61

NOTE.—The average of the seasons in the second column from the left of the table is for forty years, and the averages in the third, fourth, fifth, eleventh, twelfth, thirteenth, and fourteenth columns, counted from the left, are monthly averages for forty-one years; while the sixth seventh, eighth, ninth, and tenth are for forty years. Spr. means "Sprinkle."

In the foregoing table the rainfall is given for each rainy season, which includes parts of two consecutive years, as shown by the double dates in the first left-hand column. The second column from the left gives the total fall for each season, and the remaining columns give the amount of rain falling in each month of the seasons given by full numbers in column 1.

On inspection of column 2, it is seen that the falls for the seasons of 1850–51, 1856–57, 1863–64, 1870–71, 1876–77, 1881–82, and 1887–88 indicate very dry years, and that the intervals between them were six, seven, seven, six, five, and six years, respectively. The average of the intervals between the dry years during the entire period covered by the table is six years and two months. It is seen that these driest seasons are always accompanied by one or two moderately dry ones.

The average seasonal fall for the entire period was 19.57 inches. This quantity is near enough to be called 20 inches, and the table shows that in each of twenty-three years the rainfall fell below the average for the whole period, the mean amount for the deficient years being 14.19 inches, or about 5½ inches less than the total average. In each of seventeen years of the observed period the rainfall exceeded the general average, the mean for the seventeen years being 25.8 inches. This exceeds the annual average for the whole period of observation by 6 inches, and the average of the deficient years by nearly 12 inches.

Within the entire period the annual rainfall has exceeded 30 inches five times, varying from 32.27 to 36.36 inches, the latter fall occurring in 1852, and the rainfall has, in four years of the observations, ranged as low as from 8.96 inches to only 4.71 inches, the latter in the year 1850. Therefore the quantity of the seasonal rainfall at Sacramento has varied as much as 31.65 inches.

The bottom line of the table gives the averages of the rainfall for the whole period of observations, as before stated. The figures at the foot of the second column from the left-hand side show the average of the seasonal falls, and the remaining figures on this line, from left to right, give the average monthly falls.

It will be seen from a study of the monthly falls that the average rainy season for California extends from about the beginning of November to the end of April, a period of six months, and that the months from May to October, inclusive, are dry ones, the year being thus naturally divided into two equal parts, one rainy and the other dry.

The peculiarities of California rainfall, as shown by the Sacramento observations, while holding good to a greater or less degree for the entire State, are especially characteristic of the Sacramento and San Joaquin valleys and of the desert plains.

For the purpose of showing the range and variable nature of the rainy seasons in those valleys and on the deserts, the following table of the results of observations in California, compiled by the Chief Signal Officer and reported[1] to the United States Senate by the Secretary of War, is given:

TABLE II.—*Showing the range and variable nature of the rainy seasons in the Sacramento and San Joaquin valleys and on the deserts of California.*

Name of place of observation.	Greatest rainfall.	Least rainfall.	Average rainfall.	Period of observation.
IN THE SACRAMENTO VALLEY:	*Inches.*	*Inches.*	*Inches.*	*Years.*
Colusa	32.84	9.20	16.99	Fourteen.
Marysville	26.86	6.65	16.62	Seventeen.
Knights Landing	24.08	9.67	14.36	Ten.
Woodland	25.32	5.13	15.22	Fifteen.
Sacramento	36.36	4.71	19.57	Forty.

[1] Ex. Doc. No. 91, Fiftieth Congress, first session, 1888.

TABLE II.—*Showing the range and variable nature of the rainy seasons in the Sacramento and San Joaquin valleys and on the deserts of California*—Cont'd.

Name of place of observation.	Greatest rainfall.	Least rainfall.	Average rainfall.	Period of observation.
IN THE SAN JOAQUIN VALLEY:	*Inches.*	*Inches.*	*Inches.*	*Years.*
Stockton	22.04	6.87	13.91	Thirty-four.
Tracy	14.68	2.91	8.84	Seventeen.
Livermore	22.75	6.01	13.81	Do.
Modesto	13.54	2.25	8.89	Do.
Merced	30.83	3.03	11.75	Sixteen.
Fresno	16.62	4.87	8.79	Ten.
Visalia	13.10	3.95	9.25	Sixteen.
Tulare	11.65	3.07	6.64	Thirteen.
Delano	11.52	1.41	6.22	Twelve.
IN THE VICINITY OF RIVERSIDE:				
San Bernardino	37.51	9.98	16.17	Sixteen.
Colton	23.35	5.43	9.31	Eleven.
Riverside	22.54	2.94	9.37	Six.
Los Angeles	32.16	3.97	16.03	Sixteen.
San Diego	25.97	3.71	10.26	Thirty-seven.
DESERT STATIONS:				
Mojave	9.96	0	4.05	Eleven.
Daggett			3.97	One.
Needles			6.17	Do.
Indio	.62	0	.12	Ten.
Fort Yuma	7.04	.85	3.40	Thirty-six.

The average of the fourth column from the left-hand side of the table for the Sacramento Valley is 16.55 inches; for the San Joaquin Valley, 9.79; for the vicinity of Riverside, 12.23, and for the desert stations, 3.54.

The foregoing tables show very clearly that the valley lands of California here described have a dry climate and should be classed as arid. That their owners so classify them, from Colusa, in the Sacramento Valley, southward, is seen in the efforts made to bring them under some system of irrigation. These lands, in a state of nature, are devoid of pasturage away from the banks and low-lying lands along the main streams, and put under cultivation can be made to produce a wheat crop only about once in three years. The practice is to crop the land one season and let it lie fallow the following one, but it often happens that the third season is so dry as not to produce a crop. Wheat raising is, therefore, an uncertain and usually disappointing business in these valleys when made to depend upon the natural rainfall for its success. The meager yield of an acre of wheat, even at its best, leads to large land holdings, that the quantity secured may be sufficient to make the business profitable.

CHARACTER OF SOIL OF DISTRICTS WHERE IRRIGATION IS PRACTICED.

The districts of California in which the practice of irrigation is attended by the largest results are the orchard regions, ranging from Woodland, in Yolo County, to Stockton, in San Joaquin County.

These include the region about San Jose, in the Santa Clara Valley; the Fresno region and Kern County, in the San Joaquin Valley, and the Riverside district, in the valley of the Santa Ana.

The first-mentioned district, extending down the valley of the Sacramento to the bay of San Francisco, and thence up the San Joaquin to Stockton, possesses a very rich, deep, alluvial soil in all its lower portions along the margins of its river channels, which soil spreads out widely along the shores of the bay. The surface of these valleys rises on a gentle grade from either side of the river channel toward the foot of the mountains, and this grade has an increased rate of inclination as the surface nears the foot of the mountain slopes. As the valley surface rises the alluvial soil gradually gives way to soil washed down from the mountain slopes. This consists of quite a large proportion of clay, containing vegetable matter, with sand and gravel intermixed with it. This soil is in general called by the Mexican name "adobe." It readily soaks full of water, aided by the sand and gravel it contains, and as soon as the surface dries it becomes "baked," and is then about as hard as the "soft-burned" brick of our kilns.

The first of the districts mentioned as lying in the lower portions of the Sacramento and San Joaquin valleys, not having enough rain to insure the common range of agricultural crops, is largely devoted to fruit production, with occasional wheat crops. The fruits produced are the peach, plum, prune, apricot, cherry, grape, and the common range of small fruits.

The orchards are irrigated by means of windmills pumping from wells, in which water is reached at a depth of from 12 to 14 feet. The quantity of water used varies from 11,000 to 12,000 cubic feet a month during the four driest months of the summer. The total amount applied is sufficient to cover the land irrigated 13¾ inches deep in that time. In some cases, where steam is employed to do the pumping, the land so irrigated is covered 3 feet in depth during the growing season, with a manifest advantage in growth of trees and crop yield.

In the region of San Jose the soil is a strong "adobe," with much gravel and sand, constituting a prime fruit land. The whole region is devoted to the production of the same range of fruits as before described. The water used in irrigation here is pumped by steam power from a depth of about 80 feet, and the quantity used in four months (from May to August, inclusive) would cover the land 16 inches deep. In 1892 this section was visited by a heavy rainfall, amounting to 35 inches, and yet there were orchards in which 16 inches more were added by irrigation, with the result that those so treated yielded, by careful measurement, 33 per cent more fruit than did those alongside of them which were not irrigated.

In the Fresno region, which includes Kern County and the Bakersfield districts, a large range of soils is to be found, varying from rich, black, sandy alluvium to almost pure clay, without sand or gravel in its composition. The richest of these soils is found along the middle and upper portions of the Kings River and Kern River deltas. West of these, in the central portions of the San Joaquin Valley, the adobe clays predominate and border the marshy lands which extend around Lake Tulare; eastward from the deltas, among the foothills, a red clay is plentiful.

AMOUNT OF WATER USED IN IRRIGATION.

Thirty years ago, when the first settlement was made where now stands the town of Fresno, well water was obtained by digging 60 to 80 feet deep. Since that time the water of Kings River has been brought out over the delta for irrigation purposes, the effect of which has been to fill up the subsoil to such an extent that over a very large area the ground water is within a few feet of the surface, and in order to have dry cellars in the town they must be cemented. The old wells, 80 feet deep, are now full of water to within 6 feet of the surface. This condition of the subsoils of the delta has brought about a great change in the method of irrigation, and has greatly lessened the quantity of water used for that purpose. At first the dry soils took the large amount of a miner's inch per acre, applied throughout the year. This is equal to one cubic foot of water a second applied to 50 acres during the entire year, which quantity would cover that amount of land 14 feet 5¾ inches deep in that time, and then it no more than sufficed for the purpose of crop production on those thirsty soils. Now, with few exceptions, the water is not applied all over the surface, but is allowed to seep through the soil from ditches alongside of or passing through the fields. This is very effectual in all the sandy alluvial soils of the region, and the quantity used is very small, for it is estimated by those who are capable of judging that 1 cubic foot a second now suffices for the irrigation of 500 acres.

In Kern County and about Bakersfield much very sandy soil is found, and on the north side of the ancient channel of Kern River there is the same character of subsoil as in the case of the Kings River delta. Here also, when the region was first settled, well water was only to be had by digging about 60 feet for it, while now, after about twenty-five years of irrigation of the surface, the ground water ranges only 12 to 20 feet below the surface about Bakersfield. West of that town from 7 to 12 miles it has in many places come to the surface. Where such is the case no irrigation is needed for orchards that are on ground 5 or 6 feet above it. Quite the contrary condition exists over all the irrigated country to the south of the old river channel, for no ground water has ever been found under it at any reasonable depth, nor does the subsoil fill at all by reason of the irrigation of the surface. Hence the maximum quantity of water is used in the irrigation of these lands, amounting to as much as a cubic foot per second to 100 or 150 acres.

The maximum quantity applied to the lands on the north side of the old channel is 1 cubic foot a second to 250 acres, the supply supposed to be continuous throughout the year, and this will cover 250 acres 34 inches deep in that time. The former quantity stated as applicable to the south of the old river channel in the same length of time will cover 100 acres 87 inches deep and 150 acres 58 inches in the space of one year.

The agricultural and horticultural products have a wide range, the principal being wheat, oats, barley, corn, potatoes (two crops a year), alfalfa (six crops a year), pears, cherries, peaches, apricots, plums, prunes, raisins, table and wine grapes, olives, and figs. Citrus culture is not far advanced, but a good beginning has been made.

The Riverside district is the leading orchard region of the State, owing to the wide area developed in such cultivation. It comprises a great extent of country, ranging from Los Angeles eastward to Beaumont and Benning, and from San Bernardino southward to San Diego. The soil of its valleys is very sandy, much of it being a rich, black, sandy loam. That of the bluffs and high table-lands bordering the valleys consists of adobe clays, with a mixture of sand and gravel.

In the Redlands district the soil consists of a stiff red clay, with a coarse, sharp granite sand intermixed. It is from the color of the soil that the town derives its name. In general, the subsoils of this district consist of clays, gravel, and sand, in varying proportions, but with a very open texture, so that the high lands are deeply underdrained.

About the town of Riverside much light sandy soil is found, and this characteristic occurs in many other places on the high lands. As the light soils alternate with those of heavy clay, these conditions have led to the use of varying quantities of water in irrigating them.

The sandy soils take up the most water, and the clayey ones the least, the former parting with it the most rapidly, and therefore needing the most frequent application of it. A cubic foot per second is applied to 150 acres, which would cover that area 58 inches deep in one year. This is the allowance for the light sandy soils, while the heavier soils receive the same quantity of water to each 250 acres, a year's supply at this rate covering that area to a depth of 34 inches.

As will be seen by an inspection of Table II, the rainfall of this district varies greatly. San Bernardino has the greatest amount, a fact which is due to the close proximity of the high snow-clad peaks of the mountain range, which derives its name from the town. At Los Angeles is the next greatest fall, due to the close approach of the Pacific Ocean to that point, with no intervening mountain range.

For the interior of this district the rainfall ranges at about the minimum of the table. Small as it is, 10 inches or less, it is considered very valuable to the farms and orchards, notwithstanding the amount of water used upon them artificially. It falls during the rainy months, as shown by Table I, and its good effects extend to the following June. When deficient, as it sometimes is, the want is seriously felt.

The principal agricultural products are wheat, barley, potatoes, beans, sugar beets, alfalfa, and common garden crops; the horticultural are oranges, lemons, limes, peaches, apricots, nectarines, grapes, cherries, plums, raisins, olives, English walnuts, and the hard and soft-shelled almonds.

HOW IRRIGATION IS PRACTICED.

For the spreading of the water in the process of irrigation there are in California four methods in use. These are (1) by flooding, (2) by basins or checks, (3) by furrows or ditches in place of the checks, and (4) by furrows run in a parallel system.

In all these methods the water to be used must be brought in the main ditch to the highest side of the field which is to be irrigated, and taken from the main by notches cut in its side.

Irrigation by flooding.—For the purpose of the first method, the water from these notches is conducted over the surface of the field by helpers, who are furnished with long-legged rubber boots and long-handled shovels. Their business is to wade into the flood of water as it flows along and cause it to spread evenly over all the surface of the field. This is done by putting, by means of a shovel, little dams across the current when it flows too freely, and removing clods and slight ridges which obstruct it. This is a work requiring great watchfulness to prevent the water from cutting channels in the field, which danger increases with the slope of its surface, and also to avoid the leaving of dry spots, for unless these be very small in diameter, they will receive no benefit from the irrigation, owing to the tendency of the water to pass into the earth in perpendicular lines and not to spread horizontally to any considerable extent.

The quantity of water used in this method of irrigation must be large enough to cause a flow across the entire field. If it can not be had in sufficient quantity for this, then the field must be divided into sections by laterals from the main ditch, so that the quantity which can be used will be sufficient to flood the sections completely in succession. For the reason that quite a large proportion of the water used in this method is liable to be lost as wastage at the lowest sides of the field, it is prudent to begin, in the case of a divided field, with the uppermost section, in order that the surplus may be carried into the next lower lateral and added to the quantity which will be let out of that lateral upon the succeeding lower section, and so on.

When, in flooding the land, the plan by sections is used, it saves much of the water which is lost by working without them, for the reason that the operator can graduate the quantity applied, making it less and less, as the successive sections are flooded, by the amount of the surplus which comes down to them from the upper ones. The lowest section will need but a small amount over the surplus coming to it from above.

While this method is the most wasteful of the water used, it is considered by all who have had large experience in such matters to be the most effective of all plans for irrigation, as well as the cheapest.

Irrigation by basins or checks.—The basin plan is used on flat surfaces, where there is not enough slope to cause the water to flow readily in a thin sheet over the land, as in flooding or along furrows.

It is largely used in the irrigation of the cereals and of orchards, and can be applied to surfaces where the slope is not over 2 feet fall in 100 and should be used where a large quantity of water must be held upon the land until it soaks into it.

Fig. 123 shows the application of this method to the irrigation of an orchard; *d e* is the main ditch located on the highest side of the orchard, the slope of which is from left to right of the figure; *b b*, *b b*, *a a*, *a a*, etc., are solid embankments about a foot high, in this case, made by backfurrowing three furrows together with a plow, and then shaping them up smooth and true with a shovel; *c b* and *c b* are such ridges with a ditch made in the top of them, along which the water flows from notches *c c* in the main ditch, and is let into the square basins formed by the system of embankments through notches at the points marked by the curved arrows. The water is made to flow through these notches by means of a shovelful or two of earth thrown into the ditch in the form of a dam. The irregular-shaped dots in the center of the basins represent the orchard trees.

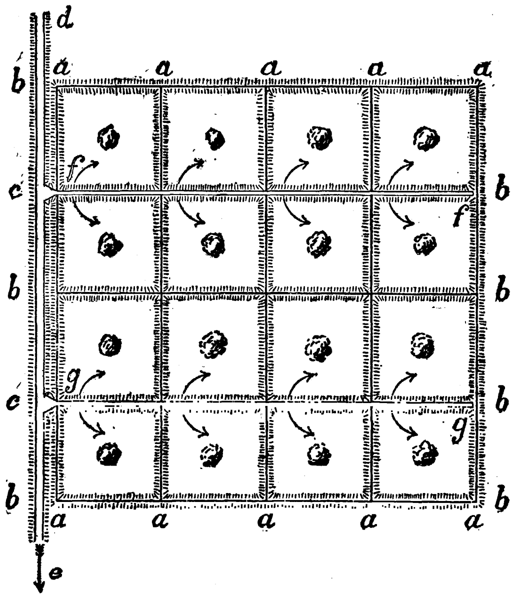


FIG. 123.—Irrigation by basins.

This method is used when large quantities of water are to be put upon lands, sometimes to the depth of 4 or 5 feet, as in upper Egypt, where the clear water of the Nile, on its first rise, is used to dissolve out of the surface soil the salts which accumulate between the cropping seasons. The surcharged waters are turned out of the basins into the river, and then the basins are filled with the muddy waters of the high flood, the slimy deposit from which furnishes fertility to the crops. Each of the basins so used incloses thousands of acres.

Irrigation by ditches.—Fig. 124 shows a modification of the basin plan, as applied to ground with considerable slope and consisting of hill-side land, wherein *f m* is the main ditch on the highest side of the field, of which *b c d e* mark the boundaries. Its surface slopes in the direction of the arrows; *o o* and *q q* are "check levees," or slight embankments, built on level lines around the curved surfaces of the field. A supply ditch, *i j*, leads the water into the "checks" or basins *b c*, *o o*, and *q q*, etc., and *t w l* is a waste ditch for discharging the surplus water from the checks when no longer needed. The "check levees," *o o*, *q q*, are usually constructed so as to be about 6 to 12 inches high, and sometimes higher.

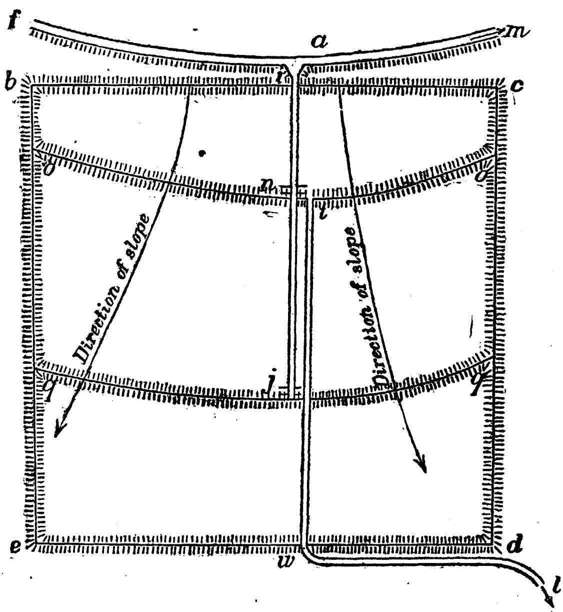


FIG. 124.—Irrigation by checks.

Fig. 125 shows the second method of spreading the water over a hill-side field, in which, as in fig. 124, *f m* is the main ditch and the slope of the hill as shown by the arrows; *t o*, *r p*, and *s q* are small ditches or plow furrows cut on a level line around the face of the hill. The water is let into the field by the short ditch at *i*, and is then spread over the space *b c t o* by means of a marginal ditch *y z*, from which it is made to flow in small streams and in a regular manner over the space between it and the lower ditch *t o*. This is done by men wearing rubber boots and furnished with shovels as in the first method. The surplus water runs down to the ditch *t o*, and is caught by it and held until it is full and the water

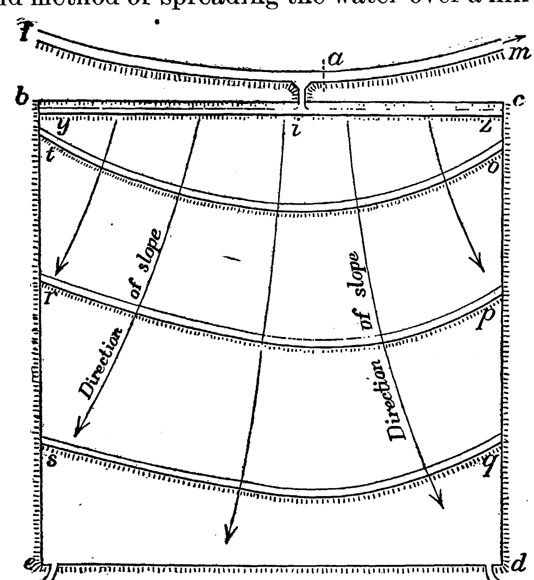


FIG. 125.—Irrigation by furrows.

runs over, which it will do all along *t o*, as it is level from end to end. It is now the work of the irrigationist to cause it to spill evenly across the space *t o r p*, covering every part of it as in the case of flooding first described.

This operation must be done by causing the water to flow very slowly from one spreading ditch to the other over the whole field, and the supply at *i* must be shut off before the flowing water has quite reached the lower side of the field *e d*. If this is not done at the right time, the loss by wastage may be very great. At *e* and *d* in the figure are represented two waste ditches, whereby the surplus water may be discharged from the field.

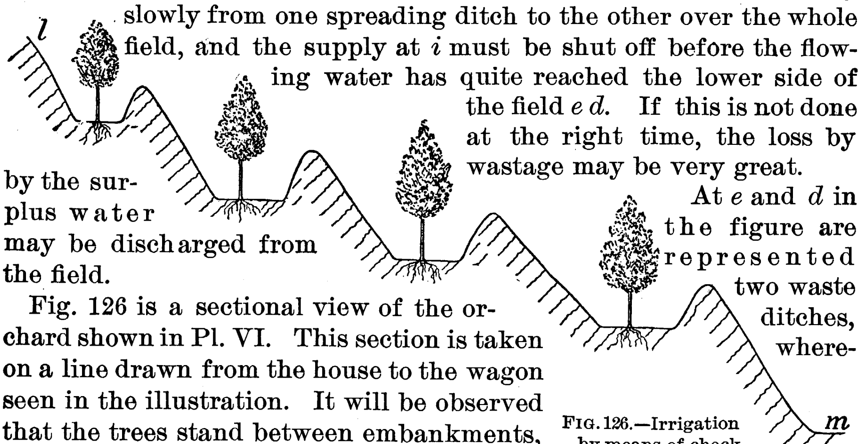


FIG. 126.—Irrigation by means of check levees for orchards on sloping hillsides (sectional view).

Fig. 126 is a sectional view of the orchard shown in Pl. VI. This section is taken on a line drawn from the house to the wagon seen in the illustration. It will be observed that the trees stand between embankments, the object of which is to hold water applied in irrigating them until it soaks into the soil about their roots. This is the only method by which sufficient quantities of water can be applied to steep sidehills long enough to accomplish the purposes of irrigation. The plan is the same as that shown in fig. 124.

Fig. 127 is a section of the hillside also shown in the same plate, beginning at the left side of the picture and running down to the wagon, and shows the method of irrigating steep slopes by terraces. The water is brought to the highest part of the hillside to which it is to be applied; the sidehill being cut into a regular system of level terraces, each bench having a small ditch at the foot of the slope on the inside, and a slight embankment on the outside of it. The ditch catches the water as it comes trickling slowly down the steep slope above it and causes it to spread evenly over the level bench, and the little ridge on the outside of this bench holds the water back for a time until it has sufficiently soaked into the soil. Care must be taken not to allow the water to cut channels on its way down over the steep slopes of this system.

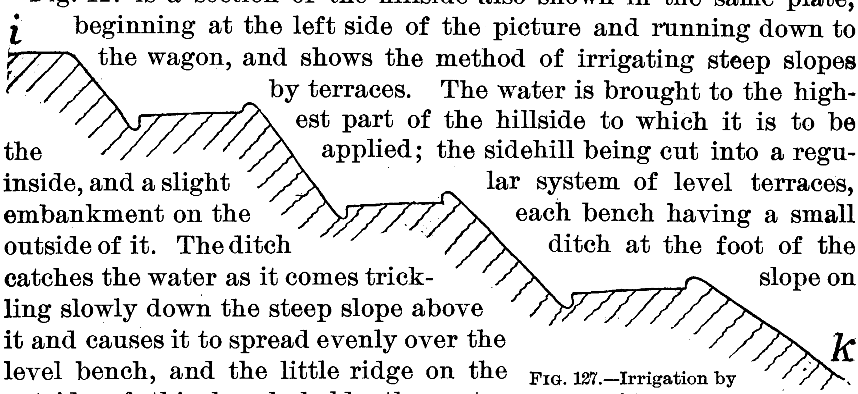


FIG. 127.—Irrigation by means of terraces on steep hillsides (sectional view).

Irrigation by furrows.—The fourth method, by furrows, is used largely in the irrigation of orchards, and is applicable to all crops planted in rows. The furrows are usually made with a plow; there are some contrivances by which several furrows can be made at once.

For orchards it is usual to make the furrows 2½ feet apart from center to center and to make the system cover all the space between the rows of trees, going one way through the orchard to within 2½ feet of the trees on either side of the space furrowed.

In case of other crops and gardens, the number of furrows and their distance apart will be governed by the distance between the rows of plants. This is the most simple and economical method in the use of water for irrigating purposes, and is the one to use in all cases in which the water supply is small. The furrows are filled with water from end to end. That this may be done, they must be level throughout their extent. When the supply given them has been absorbed by the soil, another can be given them, and so on until the proper quantity has been furnished.

In all these methods the field irrigated should have a border embankment thrown up all around it on its boundary line, to prevent the water from escaping to the lands adjacent, in which case it might cause serious damage. Then, too, there should always be provided an escape ditch through which the surplusage can be carried off to a stream or waste canal. (See Pl. VII.)

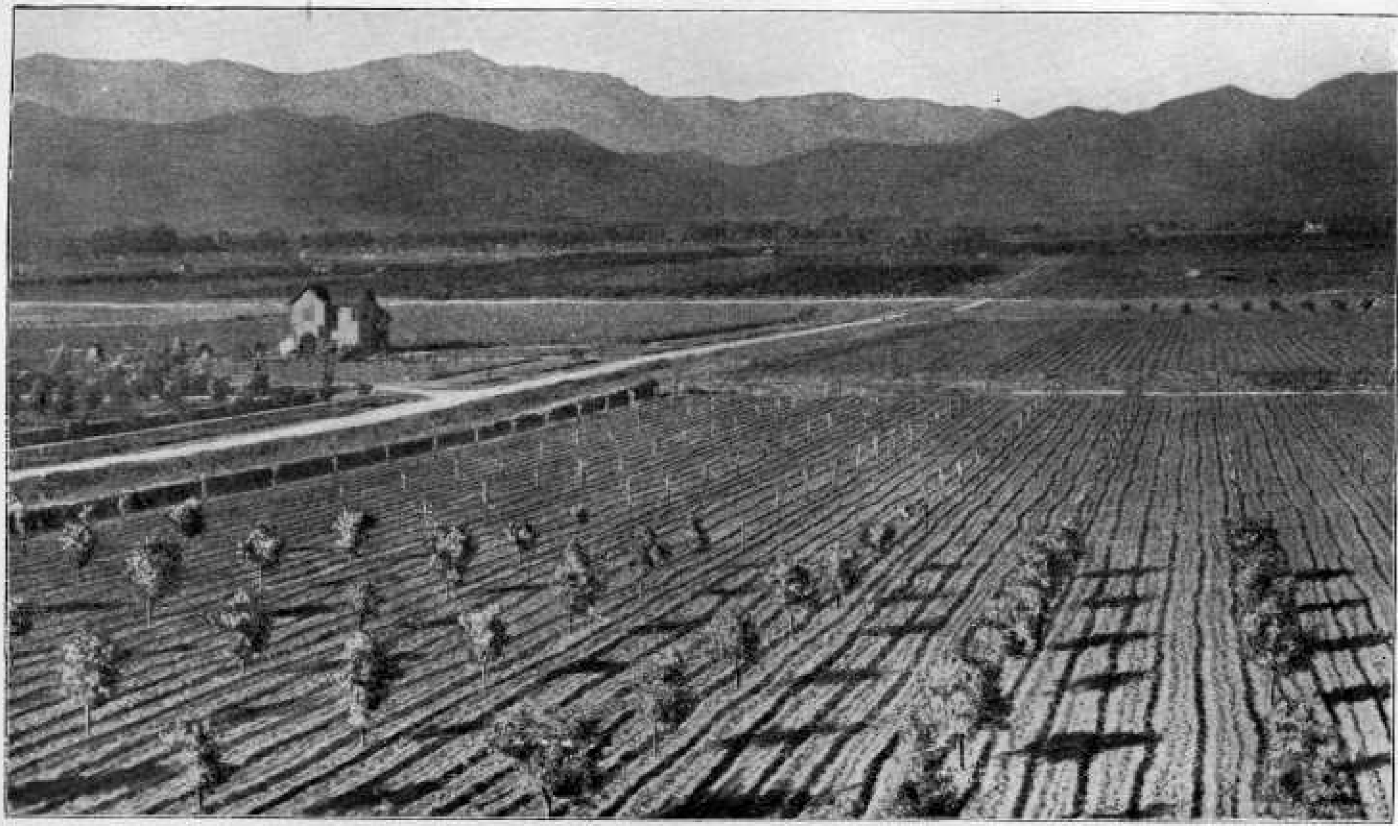
It is usual among irrigationists to use the term "irrigating head" when speaking of the quantity of water to be handled in irrigating a given field.

It is found in practice that the smallest quantity of water that can be made to flow far enough to be useful is one-half a cubic foot a second. This quantity is chiefly applied to the irrigation of gardens and very small fields. For field irrigation the quantity for one man to "handle" varies from 1½ to 6 cubic feet a second, which quantities would be called one and four irrigating heads, respectively.

The average of the usage in this regard is about 1½ cubic feet, or one irrigating head, a second. After the water has been applied in any case, and the soil has come into condition to permit of it, a careful and thorough cultivation of the surface must be given. In the case of most soils this is imperative, in order to prevent "baking," that is, a hardening and drying by the sun's heat; also to prevent undue evaporation, which a finely pulverized condition of the surface holds well in check. Such cultivation also keeps the ground clear of weeds, which otherwise grow rapidly on irrigated lands.

PLAN OF IRRIGATION BY TERRACES SHOWN AT THE LEFT OF THE RAVINE AND AN ORCHARD IRRIGATED BY CHECK LEVEES ON THE RIGHT OF IT.

PLATE VII.



FURROW SYSTEM OF IRRIGATING AN ORCHARD IN CALIFORNIA.