IRRIGATION
FOR
THE FARM

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BY

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WHEN AND HOW TO IRRIGATE, ETC.

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PREFACE.

The great importance of artificial irrigation to the Agricultural development of our Country, and the manifest need of some simple guide to the proper application of water to field crops, has prompted the preparation of this work. It is written for practical men, and especially to assist the beginner in farming by irrigation. The limits of the work have precluded extended discussion, and mere theories have been avoided as much as possible.

GREELEY NURSERIES AND GARDENSIDE FRUIT FARM, A. E. G.
Greeley, Colo., May, 1889.

GENERAL REMARKS.

The essentials to best results in all branches of Agriculture under irrigation are, deep stirring of the soil, and thorough preparation of the ground in advance of planting. In farming by irrigation it should be understood at the outset, that results will always depend vastly more upon the ability to command and apply the water at *the right* time, than upon the quantity of water used, though the supply be ever so abundant.

Again plowing and sowing should be done, and the arrangement of the crop be such that the things to be grown may receive water according to their needs. In other words, they should not be so mixed that irrigation has to be indiscriminate, regardless of requirements or results. This will be apparent when it is known that some things need vastly more water than others, and at a different time, and further, that while one method of irrigation would be necessary for one crop, it would not only be improper, but might prove fatal, to another. The small grains and grasses for example have to be flooded. The hoed crops as a rule require later irrigation and a different system. So too, the hoed crops differ in themselves with respect to moisture requirements. Hence, it is important to plant with these precautions in view.

TURNING ON THE WATERS.

THE DUTY OF WATER.

The question is often asked: " How much water is needed to each acre of farm land ? "

The question is too indefinite to admit of an intelligent answer. In the first place, crops differ with respect to moisture requirements. For example, oats and wheat will require more than rye and barley; and buckwheat, amber cane and corn, still less than the other grains. Again, " So many conditions are to be taken into consideration in determining how much water may or may not be needed for any given crop, and so little thought has, until quite recently, been devoted to the matter of economizing water, that little data that is at all reliable can be given. Broad generalization, bordering closely on to 'guess work,' has been the rule. That there are difficulties in the way of arriving at accurate conclusions in these investigations, must be seen at a glance. Local conditions, character of the soils, slope of the land, cultivation, humidity, evaporation, precipitation, drainage and capillary action, are so widely at variance in different localities, that there is small hope of getting any formula that will admit of extended application. Then, too, the demands of plant life are variable." *

The cubic foot per second is the unit of measurement usually adopted in the distribution of water from or by the

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* NOTE.—For a further discussion of this subject see " Horticulture by Irrigation," pages 9 to 14 inclusive.

large irrigating canals of Colorado. A quantity of water equivalent to a continuous flow of one cubic foot per second, during the irrigating season of one hundred days, will usually irrigate from fifty to sixty acres of land. It will often do much more than this.*

The duty of water is constantly increasing in nearly every portion of the country where irrigation is practiced. To-day in Colorado, some engineers and canal companies are making the standard of duty nearly double what it formerly was here. But the crops grown, the system used, and the means of applying water, all cut a very important figure. Where flooding takes thousands of gallons, the furrow system only requires hundreds, and sub-irrigation tens of gallons for a similar area.

Setting aside the question of the actual quantity of water used or needed for irrigation, we find that even comparing the flow of water allotted to farmers for as long as they like there are the widest differences. "Taking the flow of one cubic foot to the second (available during the season for cereals of Colorado and all the year round for the orchards of California) without making allowance for different rainfalls, this supplies in Colorado fifty-three acres; Italy 70.2 acres (Col. Baird Smith). Utah, San Barnadino, Cal., and France 80 to 100 acres. San Gabriel, California, 120 acres; Fresno, Cal., 160 acres; India, 150 to 200 acres, (Sira Colton) Los Angeles and Anaheim, Cal., rather over

* Note—A cubic foot of water is that quantity of water which a vessel one foot in length, depth and width will contain when filled. It is equivalent to about seven and one-half gallons. One cubic foot per second is the capacity of a ditch that can exactly fill such a vessel each second of time.

200 acres; Riverside, California, nearly 300 acres; Ontario, Redlands, Cal., Algeria and parts of India, 400 acres; Sierra Madra, Cal., 580 acres; Spain as high as 1000 acres; Pasadena, Cal., 1665 acres; and by sub-irrigation according to one or two experiments 1500 to 9000 acres." *

It will be seen then that the points which enter into anything like an accurate estimate of the *real* duty of water are numerous, and that when they are ignored any statement in the premises can have little more weight than mere guess work.

The aim should be to apply moisture so that the highest results may be secured with the utmost economy in the use of water, and this aim can never be accomplished until there is not only ample provision for storing the waters that now run to waste, but to also convey and utilize them with the least possible loss from seepage, evaporation, or any other cause.

This whole business needs the most thorough and careful systematizing.

* Report on American Irrigation by Hon. Alfred Dakin, M. P., Victoria, Australia.

WHEN AND HOW MUCH TO IRRIGATE.

One fact should be kept constantly in mind, which is, that soils as well as crops differ with respect to moisture requirements.

Cultivation, too, as already stated, will have an important bearing in determining the question of water supply. The soil that is deeply stirred and mellowed is the one that most readily diffuses moisture, and this is one of the chief aids to artificial irrigation. Such a condition of soil is the one to be sought, for any crop. It is better both for the deep and the shallow rooting plant. To get the best results from any system of irrigation one must put the plow down well, and where the cultivator and hoe are needed, keep them a-going during the growing season.

Among the small grains, oats and wheat usually require two irrigations during the season. The first time, along the last of May or first of June, or when the grain is six inches or so above ground, and the second time as it is beginning to head.

It is rarely necessary to irrigate land in order to bring grain up, but this has been resorted to once or twice in Colorado during seasons of little or no rainfall in the spring months.

Farmers dislike to resort to this, but they should not hesitate to where the heavens fail to supply the moisture needed. The rule among experienced irrigators is to use all the water they can possibly handle, and if they have not enough of their own, they often exchange with neighbors. When at the work, keep the water a-flowing and never stop for an ordinary rain until the crop is gone over.

The rains on our Western plains are deceptive, and should not be relied on to take the place of a thorough irrigation.

Oats, as a rule, require more moisture than any of the other small grains * and should be sown as early as possible in the season. In fact, it may be said of all the small grains that the sooner they are in after the soil is in good condition to work, the better. One irrigation is usually sufficient for both barley and rye. Where fall planting is done the seed should be covered deeper than in the spring.

While many practice sowing the grain broadcast, the use of the drill has its advantages, both in economy in seed and in the certainty of germination. And especially is drilling preferable when the soil is in the right condition for the reception of the seed.

Corn, amber cane, broom corn and all similar products require substantially the same treatment with respect to irrigation.

As a rule, one thorough watering will be all that is needed and sometimes this may be dispensed with if the cultivation is ample and the soil naturally moist. In all such crops, deep plowing, or stirring of the ground in advance of planting, is the one thing needful.

* NOTE.—Some have had extra large yields of oats by almost continuous irrigation, from the time the crop begins to head, until the grain begins to turn. The claim made is that this practice checks the first stand, and forces the grain to root, stool and head very abundantly.

We append a very good description of irrigation by flooding, and the essentials to the best results with this system, from the pen of a prominent Colorado farmer:*

DESCRIPTION OF IRRIGATION.

"The contemplated irrigation of a field of grain needing water, necessarily presupposes a number of things already accomplished; that the farmer is a stock holder in some large canal, taken from some river or smaller stream not far away; or, that he has hired the water for the season; at all events, that he has secured the right to its use; also, that he has constructed the lateral ditch, as we term it in Colorado, which is to convey his water from the main canal down to the border of his farm.

"If he is a wise farmer, too, and has had much experience in irrigation, the mere fact that he is presuming to use the water after he gets it into his lateral and down to his own field, presupposes, also, that before his grain came up, or at least when it was yet extremely small, he plowed sub-laterals through it with a heavy double mould-board plow much used for that purpose in Northern Colorado. These sub-laterals, of course start from the larger lateral, at the border of the field or farm to be watered. They should be from twenty inches to two feet wide on the bottom, from eighty to one hundred feet apart, according to the lay of the land; should take exactly the course unconfined water would run if turned loose upon the surface of the soil with no regard to to the points of the compass unless they coincide with the lines of drainage, a thing that very seldom

*Mr. J. Max Clark, of Greeley, Colorado.

happens, and they should proceed on parallel lines as near as may be, clear across the field to be irrigated.

"All the mouths of these sub-laterals, at the point where they intersect the border lateral, are closed with dams, or with small box flumes with gates in them, until they are needed to draw the water into the field.

"Suppose, now, that all these preliminary preparations have been made, you begin, in the first sub-lateral, on the side of your grain, making a compact dam in it, with dirt taken from its bottom, you place this dam in the sub-lateral, perhaps thirty feet from its mouth in the main lateral, from which you intend to draw water, then you strip off the bank of the sub-lateral for a couple of feet just above the dam you have made in it, and on the side from which you wish the water to flow into your field of grain.

"Having done this, you next remove the gate from the flume in the mouth of the sub-lateral, or the dirt dam as the case may be, the water now immediately rushes down to the dam you have placed below, and you must do so too, to pack the dirt on it as it begins to settle, and to put on more if necessary to prevent it from giving away.

"The water backs up, and meeting with this check, begins to fill the sub-lateral; rises to the surface, flows over the depression made in its bank; silently spreads itself through the standing grain, and—this, my friend, is irrigation.

"If your soil is comparatively smooth on its surface; if you have plowed your laterals in the right direction through your field; if you plowed them deep enough, and the banks are therefore high enough and strong enough to keep the water now spreading through the grain from breaking into the sub-laterals again anywhere below the dam; and—if you have the water, the process will now be quite simple, it will spread evenly across the space between the lateral you are using, and the one next beyond, forming a shallow silently running stream, eighty or a hundred feet wide as the case may be, and will slowly creep its way downward in the direction the sub-laterals run through the field. Where your supply of water is abundant, you can facilitate the flow by using two of these sub-laterals at once, and turning both streams into the same strip of grain, that is—flow the water from the left bank of one sub-lateral, and from the right bank of the other.

"Where the conditions are all perfect, water turned into a field of grain, in the manner described, will run thirty, forty, fifty and even a hundred rods without a change of dams. As, however, the flow can be greatly facilitated, and a more economical use of the water effected,—always a great consideration—by frequent changes, it is best not to let it run more than half an hour from the same orifice. A change is effected by going below the first dam to some point already reached by the water, and making a second dam and a second opening similar to the first. Then the first dam is removed and the bank repaired, and thus the operation goes on until the whole field is completed.

"A simple contrivance, called a 'canvas dam,' has of late years come into use, which greatly lessens the labor of making these small dams. It consists of a piece of heavy canvas ducking, about a yard and a half by two yards in size, made up in the form of a window curtain, with a pole through a tuck in one end. In use, the rod or pole in the canvas is dropped across a sub-lateral, at some point where a dam is required, the flap or bottom end of the curtain extending up stream in the lateral. A little earth is now placed upon the edge to hold it down when the water strikes it, and the dam is complete.

"To remove the dam, the cross pole is seized in both hands and pulled up stream, when it is rolled backward through the water, the bottom at once becomes loose and the current passes to the next canvas already placed below."

SYSTEMS OF IRRIGATION.

Although the two systems of irrigation (by flooding and soakage by the furrow) are the ones generally used on the farm at the present time, it seems only a question of not many years, when other systems will be adopted quite largely. Instead of open canals and laterals, water will be conveyed by pipes and conduits or through enclosed channels, and made to do more than quadruple duty by under surface application.

In the artesian belts, great flowing wells will supply the average farm, and even large tracts with an abundance of water, as they are now doing in portions of California, * but these must be utilized in connection with a proper system of reservoirs or storage. In fact, the irrigation of

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* A fair flow is struck at an average depth of 400 feet and afterwards other flows are reached at short intervals, and experience has thus far shown that any quantity of water required can be obtained by going deep enough. Many wells will irrigate a section of land, and there are a few that will suffice for several, or perhaps for three or four thousand acres, if the water were collected in reservoirs and properly applied. The wells on Miramonte are among the very largest.

In the northern part of the Artesian Belt, just south and southeast of Tulare Lake, there are known to be thirty-four wells within a radius of ten miles; some deep and others shallow, as more or less water is wanted, Among the deep ones, in that district, with their average flow each for twenty-four hours, and the names of the owners of the land upon which they are situate, are the following: Brusie, 2,000,000 gallons; Haley, 2,400,000; Spring, 2,000,000; Mays, 1,200,000; Robinson, 1,000,000; Raymond, 1,500,000; Moore, 2,500,000; Moebus, 500,000; Haggin, 1,500,000; another, 1,600,000; another, 2,200,000; and another, 900,000; Hogan, 2,200,000; Arnold, 1,500,000; Smith, 3,000,000; Robinson, 2,000,000; Hutchins, 2,000,000; Miramonte Colony, 2,700,000.

the future, by whatever plan, will be synonymous with an improved and extensive system of reservoirs.

THE NEW AGRICULTURE.

It is possible that the best system of irrigation for this western country, at least, has not yet been discovered. The "New Agriculture" provides for storing the waters in parallel trenches four or five feet deep, and of the same width, below frost line, and filling in these trenches with round stones to the depth of eighteen inches or two feet, tiling to be used if stones are not to be had, then shingling over with flat stones, or tile, or timber. After which, to prevent the earth from filling up the spaces between the stones, any coarse material like straw, hay, weeds, cornstalks or fine brush are placed on. A heavy coating of manure may follow this, and then the excavated soil is placed on top. A series of these trenches are constructed on an incline, one above the other, about a rod apart; these main reservoirs or trenches are connected with smaller trenches, about eighteen inches from the surface, partly filled in with small stones, and designed to connect and convey the surplus water from the trench above to the one below. These are called overflow trenches. Each of these main trenches, then, becomes a reservoir capable of holding three feet or more of water before it overflows into the cross trenches. This is the method by which Mr. Cole would store and conserve the rains and melting snows for use when needed, and it affords an excellent illustration of the principle of irrigation by capillary attraction, or by the gradual and uniform raising and diffusion of moisture from below. Beyond a question it is correct in principle, and I am prepared to believe all the reports of results from experiments at the " Home on the Hillside." As to what extent this system may be utilized in other parts of the country, and under conditions widely different from those where tests have proven so satisfactory, remains to be seen. Mr. Cole not only reports amazing yields under the system, but claims remarkable immunity from disease for all products grown in that way. The expense of fitting the land for this plan amounts to several hundred dollars an acre, where it has been tested, which of itself, appears almost a bar to an extended adoption of the system. But Mr. Cole does not so regard it, and writes under date of Dec. 28th, 1887: "As for cost of fitting lands; were it to cost ten thousand millions to fit under my system the soils of Colorado, as a return interest, at six per cent. would be realized, as near as I calculate, on $900,000,000,000,000,000,000. Don't vote me a crank, now, but wait." The progress of the New Agriculture will be watched with interest.

THE ASBESTINE SYSTEM.

This method of sub-irrigation was devised in California by E. M. Hamilton, and is sometimes called the " Hamilton Process." It consists of pipes made of a combination of Portland cement, lime, sand and gravel, laid at a depth of two feet below the surface of the ground, parallel to the rows of trees or vines in an orchard or vineyard. In these pipes, on the upper side, is inserted a wooden plug opposite each tree or vine, the plugs having tapering holes in the center one-fourth to three-eights of an inch in diameter, through which the water finds exit. Each plug is surrounded by a larger stand pipe, setting loosely on top of the distributing pipe, open at the bottom and reaching to the surface of the ground, for the purpose of keeping the dirt away from the outlet, and rendering it accessible at all times for inspection. The pipes are connected with mains leading from a reservoir. The water finds its way through all the outlets, filling the stand pipes, and slowly percolating to the roots of the plants. No water appears on the surface.

The claim is made for this method that it effects a very great saving of water over the ordinary means of surface application; that it requires far less time and labor; that it may be used for the distribution of liquid manure; that it does not cause the ground to bake with the heat of the sun—no water appearing at the surface; that no grading is necessary; that the growth of weeds is checked; and, finally, that it induces deep, instead of shallow rooting, as is the tendency with surface irrigation.

The further claim is made that, by keeping the water from standing on the surface of the ground, injurious deposits of alkali are avoided. These points are strong, and if they can be sustained, which is by no means improbable in many localities, the system is destined to great popularity and usefulness. In many parts of California it is giving much satisfaction.

The Australian member of parliament, Mr. Dakin, from whose report we have already quoted, in commenting on this system, after a mention of the fact that irrigation beneath the surface, if not excessive, is considered the most perfect method of supplying water to vegetable life; because it can avoid the dangers of over-saturation, surface caking, and of washing out the richer elements in the soil, as well as accomplish an enormous saving in water, says: "It certainly appears that sub-irrigation is the hope of the most intelligent irrigators, because it promises a great economy of water, and the most direct application of it to the thirsty tree that it is possible to devise."

The difficulties that naturally suggest themselves in in the way of complete success in this plan are the liability to have the pipes stopped up, either by tree roots or sediment. The advocates of the system claim that both these dangers have been anticipated by ample provision for either guarding against or clearing obstructions of this kind. Nevertheless, it is probable that in some localities obstructions similar to those named might be serious drawbacks to the successful working of any system of conveying water by pipes. But that all these hindrances will ultimately be overcome, there seems little doubt.*

OTHER METHODS.

Mention has been made of Artesian Wells, which are proving so effective as a means of water supply in some regions. This method, however, must be limited to what are termed the Artesian Belts.

Wind mills and hydraulic appliances for raising water, are also being used with greater or less success, all over

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* NOTE—For the further discussion of "The Best System of Irrigation" see "Horticulture by Irrigation," pages 15 to 26 inclusive.

the land. But the steam pump promises to become a most important factor in utilizing water for irrigation purposes, where a supply can be found at no considerable depth below the surface. The best of these that I have seen or heard of are the Steam Vacuum Pumps which are now being manufactured at Greeley. This pump has a capacity of from fifty to 2,000 gallons per minute, depending on size. In point of economy it has great merit, as atmospheric pressure does the work. Runs with waste (or exhaust) steam from any engine. If run with live steam the claim is made that it will raise 50,000 gallons of water thirty feet high with one bushel of coal.

This pump seems to possess the merit of cheapness, simplicity, durability and economy in use, and the capacity to do the maximum amount of work with the minimum expense. It promises to be of especial value to fruit growers, commercial gardners, and those having small farms favorably located for utilizing the under surface water supply.

FALL IRRIGATION.

Without the soil is cold, or unusually moist from any cause, water may be advantageously applied before the winter sets in. Indeed, this practice is being adopted quite generally by successful cultivators where water can be had, and is especially to be commended in the preparation for crops which require the maximum amount of moisture, or where the water supply is likely to be short. It places the land in the condition of a storage reservoir for the succeeding season, and experience has shown that the soil that has received a thorough irrigation in the fall, or early winter, has a big advantage over ground that has not. Hence it is worth while to emphasize the supreme value of applying water at this time. Keep the ditches ready and the gates in repair, so they may be used in the fall as well as spring.

FALL PLOWING.

This is another matter that needs more attention on the part of the farmers by irrigation, than it has received. At the outset it is safe to say that some lands should not be plowed in the fall. These are the light, sandy or gravelly soils, except perhaps at breaking, when the sod may be lightly turned under. When the tendency is to dry out too rapidly or blow away, fall plowing should not be resorted to. But the heavy, tenacious soil can be better subdued by deep stirring at this season than at any other time, because it gives the frost and snows full action on the upturned soil. Besides, deep and thorough disintegration will accomplish the first step in the retention of the soil of the moisture needed.

So the claim is made that one irrigation on land that has been deeply plowed is as good as three irrigations on shallow plowed land.*

Fall plowing, like fall irrigation, will be practiced more and more in the future where conditions are favorable, and experience is showing most conclusively that excellent results may be secured by a timely use of water and the plow at this season of the year. Besides this, in

* "Horticulture by Irrigation," pages 11 and 12.

many sections of country fall seeding is done to good purpose and in all such cases it is safe to put down the implement used to a generous depth.

IRRIGATING THE GRAIN FIELD.

THE PERIOD OF IRRIGATION.

This usually begins with most sowed crops during the last days of May. Corn and similar products will not require irrigation until later.

The "flooding" system is used for grains and grasses, and the furrow or soakage system for hoed crops.

As it is not the purpose of this work to treat in detail the subject of farm irrigation, no attempt will be made to mention all the products that might be successful under a system of artificial watering. Only the leading crop staples, or those that promise to become such in the great irrigation belts of the west, will be discussed in a general way. A table given on page 58 will serve as something of a guide as to soils and the number of irrigations usually required for the farm crops most largely cultivated.

The statement is here made that in a climate like that of Colorado, on the average soil, nearly all grasses and forage plants should receive an irrigation immediately after each cutting. Meadows and grass lands, too, may be usually watered with profit as the growth is starting in the spring. While this is true, it is worth while to repeat that the determining of the frequency of irrigation is a matter that must rest largely on the judgment of the irrigator in any given case. As to soils, the ideal one is not always to be found, but if one has the deep, sandy loam, with clayey subsoil, not too heavy, he has a good starter in the direction of successful farming by irrigation. It is a very safe "general purpose" soil.

RESULTS OF IRRIGATION.

THE UNION COLONY OF COLORADO.

As this colony was the first and most notably successful attempt in this country at agricultural colonization under a system of artificial irrigation, a brief sketch of the enterprise may be of interest in this connection.

Union Colony is located in Weld County, Colorado, near the junction of the South Platte and Cache la Poudre rivers, in latitude 40° 25′ North, longitude 27° 48′ West from Washington. It was established here in 1870 by a locating committee consisting of N. C. Meeker, H. T. West and Gen'l R. A. Cameron, and soon founded what is now the beautiful and prosperous city of Greeley. The elevation of the city is something less than 4,800 feet above sea level.

The total amount of land originally occupied and controlled by the Colony was about 30,000 acres. This was acquired either by direct purchase of railroad, government or individuals, or by special contract for the control of such land for a stated period.

The town proper comprised some 800 acres, which was subdivided into 1,500 lots and blocks. The land outside the town limits was divided into five, ten, twenty and forty-acre tracts, according to the distance from the business center. These tracts were deeded to members of the Colony, with a perpetual water right from the irrigating canals (to be built) in consideration of the payment of

$150 for each, this amount being the membership fee. This membership also entitled the holder to the right to purchase both a residence and business lot in town at a reasonable figure, on condition that improvement was made on the same within a limited time.

Those members of the Colony who bought railroad land, or filed on government tracts were permitted to buy perpetual water rights on the basis of $150 for each eighty acres.

The proceeds from the sale of lands, lots and water were used for various public improvements, like constructing canals, erecting a fine school building (at a cost of $30,000), laying out and grading streets, planting trees, etc.

The first canal was built in 1870 at an original cost of $10,000. It was ten miles long, with a grade or fall of three feet to the mile. Its capacity at first was fifty cubic feet per second, but later enlargements have more than doubled that capacity and increased the expense to about $25,000.

The second canal was built in 1871, and has cost up to the present time about $80,000. It covers some 25,000 acres of land, is thirty miles in length, has a grade of three and two-tenths feet per mile, with a capacity of 585 cubic feet of water per second. It is now twenty-five feet wide on the bottom and for the first ten miles carries four and six-tenths feet in depth. The annual cost to the owners of land under this canal for the maintenance, superintendence and necessary improvements has been from $10 to $24 for each eighty acres. The smaller subdivisions are proportionately assessed for the same purpose.

Water rights have advanced rapidly in value and are to day worth from $1,000 to $1,400 per eighty acres. The larger of these two canals is now owned and controlled entirely by a corporation composed of farmers operating under it, the Colony having some years since transferred its interest and control to this company.

The maximum quantity of water in these streams fed by the mountain snows is reached in June and July, and these are the months of greatest activity among irrigators.

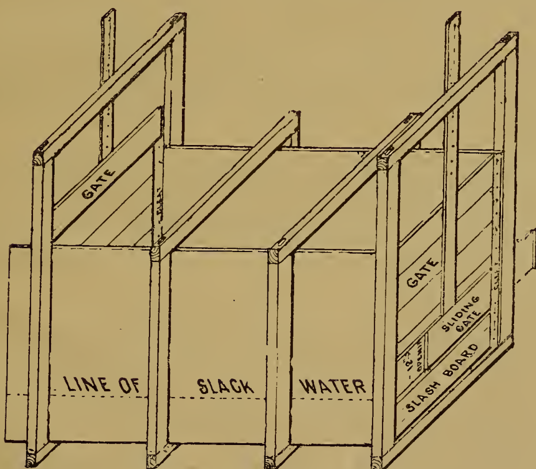
One cubic foot of water per second is generally used on from fifty to sixty acres of land around Greeley; but farmers often facilitate irrigation by exchanging with each other, so that they frequently use two or three water rights on an eighty-acre piece.

The amount of water flowing in the river each day is known by means of a gauging station located above all the canals, and this enables the water commissioner to assign to each canal the quantity of water to which it is entitled. This in turn is subdivided and apportioned to users by the superintendents of the various canals.

The principal farm crops are wheat, oats, corn, potatoes and alfalfa. The soil is lasting and very productive under a judicious rotation of crops. Vegetables and small fruits are also grown abundantly in and around the city. Special varieties of standard fruits also do well.

Mixed farming is now receiving considerable attention and irrigation is being more thoroughly systemized each year.

The success of Union Colony may be attributed mainly (1) to the moral and intellectual character of its members, (2) to the integrity of the financial management, (3) to the fundamental law incorporated in every deed prohibiting the traffic in intoxicating liquors, (4) to a reasonable co-operative basis and (5), but not least, to a location combining many natural and desirable advantages.



A VERY GOOD IRRIGATING FLUME.

IRRIGATION LAWS.

Notwithstanding considerable legislation has been had and constitutional provisions enacted, in Colorado, upon matters pertaining to water distribution from the streams of the State, important questions are constantly arising that must be met, not only by the courts, but by law makers as well. Hence, existing laws can scarcely be said to be ample to cover and protect all of the interests involved.

Artificial irrigation is becoming a highly complex and important system, and may be fairly said to lay at the very foundation of the prosperity of many States and Territories of the West. More than this, it is fast assuming National importance.

The system of reservoirs contemplated by the Government will become a gigantic National enterprise that will require much legislation and adjudication to perfect. Hence, existing laws may be said to be yet in a crude state. The following is given as an outline of the most important provisions upon the subject in Colorado:

Persons occupying lands in the neighborhood of streams are entitled to use the water thereof for irrigating purposes, and hence have the right-of-way to a point of the stream high enough to raise the water to a proper level.

In case of insufficiency of supply, three commissioners, appointed by the county judge, shall apportion the water to different sections on alternate days of the week.

Ditches have the right-of-way, but two ditches may not be cut through the same land when one can be made to carry the necessary amount of water.

The shortest route must be taken, and the owner must permit a ditch to be enlarged when necessary for the accommodation of other persons, upon payment of a reasonable compensation

If the channel of a stream changes, the head of the ditch may be changed accordingly. Any person constructing (or enlarging) a ditch must have recorded in the office of the county clerk a full description of the ditch, its capacity, and date of construction or enlargement, and no priority of right attaches until such a statement is filed.

Persons who have used the natural overflow from any stream have in case the supply is diminished from any cause the same priority of right to dig a ditch as if the ditch had been constructed when they first occupied the land irrigated.

Reservoirs for storing any unappropriated water may be maintained, provided no embankments more than ten feet high shall be erected without the approval of the county commissioners. The owners of such reservoirs are liable for all damages from breakage or leakage. Owners of ditches have the right to erect any machinery necessary to raise the water to the proper level. They shall maintain such embankments that the property of others shall not be damaged, and shall return the surplus water, through a tail-ditch with as little waste as possible.

Vested rights of mill-owners shall not be impaired.

Whenever a ditch crosses a public road the owner shall erect a substantial bridge, and maintain it thereafter. If not built within three days, the county supervisors must do it, and collect the cost from the party who should have built it.

Head gates must be kept strong enough to control the water, and the owner failing to keep them so is liable for all damages.

Water rates are fixed and all matters pertaining thereto determined by the county commissioners. The lands of the State are divided by law into different districts, and the governor appoints water commissioners for the several districts, who have general control and regulation of the water.

Any person willfully damaging a ditch or reservoir with intent to injure any person, or wilfully opening or closing a water gate without authority, is guilty of a misdemeanor, and subject to fine and imprisonment.

Justices of the peace have jurisdiction of such offenses, with the right of appeal.

Ditches where water is not sold for the purpose of deriving a revenue are exempt from taxation.

There are very elaborate rules with regard to location, priority of rights, and proceedings in court in cases of contests.

IMPROVEMENTS NEEDED.

The time is not far distant, let us hope, when much of the annoyance which is experienced in the construction and maintenance of open ditches, may be overcome by the use of tiling or pipes of some kind for conveying water. When this plan can be cheaply and effectively adopted it will not only prove a great saving of water, both from evaporation, seepage, natural soakage and the like, but will avoid the unpleasant consequence of breakage, overflowing and other occurrences which now demand almost constant vigilance on the part of those having the control of ditches.

In this connection observations are given from leading Colorado engineers on canal construction and water measurements. But the remark is here made, that nothing entirely satisfactory has yet been devised for measuring water in irrigating canals that is sufficiently simple and accurate for general application.

CANAL CONSTRUCTION.

This is a most important feature of any system of irrigation, for upon the proper survey and completion of the canal, often depends the honest and equitable distribution of water among those interested. This applies, not only to the main canals, but likewise, to the entire system of ditches, sub-laterals, channels, etc., by or through which the water is to be conveyed. Losses and troubles innumerable are annually occurring, by reason of the faulty construction, or lack of engineering skill in surveying the route to be occupied.*

To determine the proper form of channel, the right slopes, grades, strength of banks, the best route to follow (if a choice is given) and other things not named, requires skill and judgment on the part of the engineer. A lack in any of these essentials may cause widespread ruin and disaster.

WATER MEASUREMENTS.

The quantity of water which a ditch carries, expressed in cubic feet per second, may be obtained by multiplying the area of the wet cross-section of the ditch, expressed in square feet, by the mean velocity of the water at the cross-section selected, expressed in feet per second. †

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* NOTE.—For much valuable information on canal construction and water measurements, the author acknowledges indebtedness to Messrs. J. S. Green, C. E. and Walter H. Graves, C. E., of Colorado,

† NOTE.—A cross-section of a ditch means a vertical section at right angles to the course of the ditch.

In connection with the actual measurement of the velocity of the water, let it be borne in mind that the water does not move with equal velocities at all points of the cross-section, but that, as a rule, the velocity increases from the sides towards the center of the channel, and from the bottom upwards to a point a little below the surface of the water.

By the *mean velocity* is meant that certain velocity which, if common to all the threads of water, would produce the same discharge as that occasioned by the varying velocities which actually exist; or, in other words, it is the average of the velocities of all of the threads of water passing through the cross-section.

There are many methods, more or less convenient, of measuring the mean velocity of water flowing in a ditch. The best, and the one adopted by this department in rating measuring flumes, is that in which a current meter is used. The current meter is a machine which registers the number of revolutions which a vaned wheel when, submerged in running water, makes in any observed number of seconds. The number of revolutions divided by the observed number of seconds, gives the number of revolutions of the vaned wheel per second. As the meter, before being used, has been rated, so that the velocity corresponding to any number of revolutions per second of the vaned wheel is known, it follows that by its use the velocity of the water at any point of the cross-section can become known. The average of the velocities obtained by a number of observations at the proper points, will give the mean velocity of the water through the entire cross-section.

To obtain the maximum surface velocity, select a portion of the ditch, near its head, which is free from weeds, and from eddies, still water, and other irregularities, and which is as nearly straight and of uniform cross-section as can be obtained for, say a distance of 125 feet, then lay off a line, 100 feet in length, parallel and adjacent to this part of the ditch, mark the ends of the 100-foot line by stakes; use for a float a chip, or small block of wood, of such form as not to catch the wind or project far below the surface; cause the float to remain in the swiftest current throughout its course; place it in the current some distance above the upper end of the 100-foot line, so that it will have acquired the velocity of the water by the time it reaches that point; start the stop-watch, or note the time, when the float passes the upper end of the 100 foot line, and stop the stop-watch, or again note the time, when the float passes the lower end of the 100 foot line; 100 feet, divided by the number of seconds it took the float to run that distance, will give the velocity of the float in *feet per second.* (Illustration: If it took twenty-five seconds for the float to run 100 feet, the float would run $\frac{100}{25}=4$ feet per second; if forty seconds were required for it to run 100 feet, its velocity would be $\frac{100}{40}=2.5$ feet per second.) Repeat this operation several times, in order to be positive that the *maximum surface velocity* has been obtained.

The form of channel is determined largely by the object or purpose of its construction; that is, if to be used to deliver water at a certain point some distance from its head, a trapazoidal form is generally adopted, set rather deeply into the ground, and with a bottom width of from two and a half to three times its depth, this character of channel giving the greatest carrying capacity and least liable to destruction and casualty. This form of channel is also used on steep hillsides, with but one bank, the lower one.

If, however, it is the purpose to distribute water to the adjacent land along the course of the canal, the channel should be shallower, to have the water at all times accessible, the depth usually one-eighth or one-tenth the width. When the channel crosses an open, comparatively level plain it is made partly in excavation and partly in embankment, and has the appearance of parallel railroad grades with a burrow pit intervening.

In this form a comparatively small amount of excavation gives a large cross-section, and can be cheaply constructed, although it is a channel that is peculiarly liable to destruction.

In loose, sandy or gravelly soils, the side slopes are usually two and one-half or three to one; in firm, stiff soils, one and one half or two to one, and in rock, from a fourth to one to one to one. In the large canals it is customary to slope the bottom towards the center, which is from one to three feet deeper than the sides

The matter of slope or grade is always a perplexing question. If the water is to be carried some distance before it is to be used, a general rule might apply, viz: To give the channel all the fall the soil will stand, as the greater the slope the more rapid the current, and the greater the velocity the greater the delivering capacity. This would, of course, lessen the size of the canal required, therefore the cost of construction. But on the other hand it would lengthen the canal, cause it to run lower and cover less land. To correctly determine the dividing line between an excessive cost of construction in order to embrace more territory on one hand, and too great a sacrifice of territory to the cost of construction on the other, is a matter that will call for the exercise of the engineer's best judgment.

However, these matters, as well as most others in canal construction, are determined by financial considerations rather than by other conditions; that is, the financial factor is the controlling one of the problem, and stringent finances may often be more responsible than poor engineering for bad results.

Grades and slopes generally range between 1 in 6,600 or .000151, and 1 in 1,760, or .000568.

The Citizens canal, in southern Colorado, has a fall of 1 in 10,560, or .0000947 along a portion of its course—six inches per mile. This is probably the least slope given to any of the large canals, and the greatest may probably be found in the rock cuts of the Del Norte canal, which has a fall of about thirty feet per mile. Of course, nothing but rock could stand such a current as this.

The larger the volume of water the less the slope necessary to give it a required velocity, so that when the nature of the soil is known, and the velocity of current that it can stand, then, with the volume of water fixed, the grade-slope can easily be determined.

With too sluggish a current the canal soon chokes up with water-grass and weeds.

The velocity of current generally sought is from three feet to five feet per second.

In the alignment, while it is necessary to follow the grade line contour in a general way, to adhere to it exactly would give a degree of sinuosity and in many instances such sharp, angular bends that the flow would be greatly impeded. It is often better to shorten the course and make it more direct, even at an additional cost in cuttings and embankments. Of course, the direct line is the shortest, the delivering capacity of a straight channel is greater, and the wear and tear is less.

LIST OF GRAINS, GRASSES, ETC., FOR GENERAL PLANTING.

WHEAT.

Defiance, White Russian, Blounts No. 15, Saskatchan, Fife, Spring Wheat.

OATS.

White and Black Russian, White Welcome.

BARLEY.

Hulless—Common six-rowed.

RYE.

Mammoth Spring Rye, fall or winter.

CORN.

Improved Pride of the North—Early Dakota—Improved Leaming.

POTATOES.

Beauty of Hebron—Rose Seedling—Early Rose—Mammoth Pearl—Snow Flake.

BUCKWHEAT.

Silver Hall—Japanese (for trial).

SORGHUM.

Early Amber Cane.

BROOM CORN.

Evergreen—Extra Early Japanese.

CLOVER.

Alfalfa, Esparsette, Red Clover, Alsike, White Clover.

GRASSES.

Red Top, Timothy, Orchard Grass, English Blue Grass; Hungarian, German and Common Millet.

NON-SACCHARINE SORGHUMS.

Kaffir Corn, Yellow and White, Millo Maize, Large African Millet.

FIELD PEA.

Common Canadian.

HOPS.

English Cluster.

TOBACCO.

White Burley, Connecticut Seed Leaf, Hester, Missouri Broadleaf.

PEANUTS.

White Teanestand—Savatilla—Early Spanish.

ESPARSETTE.

ALFALFA AND ESPARSETTE.

Alfalfa has become a household word among the farmers of the west. It is the great staple forage plant in at least a dozen states and territories of the country. Every year adds to its popularity. It grows and flourishes in almost every soil that is suited to any crop, and under fair conditions will take care of itself and bring better returns than any similar plant yet tested. It should as a rule be sown early in the spring on well prepared ground. The deeper and richer the soil the stronger the growth.

The seed of the best quality, free from noxious weeds and fresh, should be put in reasonably deep, at least so that it will be protected from exposure to drying winds. The drill may be used or seed sown broadcast. In the one case, about fifteen pounds to the acre will be needed, and the other case from twenty-five to thirty pounds.

If a crop of seed is to be raised, the stand should be thin.

Avoid, if possible, watering the young growth until it is a few inches high, for the reason that the ground is liable to bake and the tender leaves to sun scald. Sometimes oats and barley are sown with alfalfa, and afford a very good protection to it in making a start. From three to four cuttings are usually made in Colorado after the land is well seeded. In California, on account of the almost continuous period of growth, double this number of cuttings may be secured.

The land is usually watered early in the spring and also after each cutting. Alfalfa is a very deep rooting plant and where the soil is naturally moist, may be grown without irrigation if it becomes well established.

It is also one of the best fertilizers known to the farmers of the West. The great roots, when turned under, enrich the soil immensely, and this fact seems destined to secure for it nearly as much popularity as the enormous yields of forage it produces. It can both restore exhausted soil and furnish the elements of fertility to other soils deficient in them from any cause.

In regard to irrigation, with this as with any crop, one should be governed by the conditions of the soil. It is well to observe the precaution of not letting water stand long on the Alfalfa field, nor to freeze on ground seeded to it. Neither will it thrive long if water stands around the roots. Start the mower "just when the plant is coming into blossom" is the now pretty generally accepted rule, without, of course, seed is desired. In this case it must be allowed to mature, and should always be saved from the first cutting. "Make hay while the sun shines" is an old maxim which applies with especial force to the Alfalfa harvest. "Cut one day, let it lay in the swath and cure all the next day, rake up early on the morning of the third and bunch and place in cock; let it cure in cock from one to three days." These are about the right fair weather directions. If weather is not favorable a longer time will be needed to cure the crop. Place the hay under cover if barn or shed room is at hand. If not, stack securely so that there will be as little liability as possible to injury from rain.*

Much that has been said of Alfalfa will apply to what promises, in some parts of the land, to be its great rival—Esparsette, or Sainfoin (*onobrychis sativa*). This plant is of quite recent introduction in this country, but is of the same family as Alfalfa, and has a similar history. Esparsette, or Sainfoin, is thought to be especially adopted to light, chalky, sandy and gravelly soils, and hill slopes, and in arid sections where irrigation is not obtainable. But the hillside or mountain slope, with the limestone formation, seems to be best adapted to its culture and development.

The claim is made that it will stand dry weather far better than Alfalfa, and thrive at an altitude 8,000 feet above sea level. It is said to be the main reliance for grass in the high regions of Switzerland. It should be sown early in the spring, either broadcast or drilled, and from forty to sixty pounds of seed to the acre are recommended. Cover to depth of from one-half inch to one and one-half inches, depending on conditions of soil and chances for moisture. Like Alfalfa, it may be sown with oats, barley or other grains, and should be irrigated after each cutting. One great advantage claimed for it over other clovers is that it can be safely pastured without causing bloat. The grass and hay are of the first quality for stock and the seed itself is said to be more nutritious than oats.

Two cuttings each season are usually secured. Great

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* NOTE—Those who have the book, "Horticulture by Irrigation." will find in the special chapter on Alfalfa, pages 91 to 100 inclusive, valuable hints on pasturing, feeding, the relief of bloat in cattle, etc.

merit is likewise claimed for it as a honey plant. Enough is already known of esparsette in this country to justify a pretty thorough test of it in different sections of the land, but the claim can scarcely be made that is likely to supercede alfalfa as a hay or forage plant. The two should go together to fill the vast needs of the west in the direction of hay products and pasturage.*

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*For the cut of Esparsette shown herewith, we acknowledge indebtedness to Messrs. Bartildes & Co., of the Colorado Seed House, Denver.

CORN, CANE AND FODDER CROPS.

Field and garden corn, amber cane or sorghum, and broom corn all require substantially the same soil, culture and treatment with respect to irrigation. In the care of no other crops are the benefits of deep stirring of the soil before planting more apparent. While irrigation at the proper time is often essential to the right development of these products, they are very impatient of excessive watering, and hence there is no more certain way of retarding growth and maturity than by careless application of water. Better not irrigate at all, than to use unsparingly.

One irrigation is all that is ordinarily needed, but two are sometimes given corn. Quite often, however, under favorable conditions, no water is required to be turned on. In this latter instance, ample preparation of the ground in advance of planting, is usually supplemented by timely cultivation during the growing season.

Broom corn should be planted rather later than field corn, but the soil should be in the best possible condition. The Evergreen is a standard variety. *

One point to be observed in sorghum culture is that highly manured or fertilized soil is apt to impair the quality of the sugar or syrup if grown for this purpose.

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* The extra early Japanese variety is giving great satisfaction where tested in Colorado. It is probably the earliest known variety, and matures in about eighty days from planting. It also stands dry weather and generally matures perfectly without irrigation. Is especially valuable as a fodder crop.

The plant too when young, is quite tender and generally requires hoeing or hand work, before the cultivator can be used, and if there is a tendency to form a crust over the surface before the growth is fairly up, it is important to go over the rows with a light rake or some similar implement, and remove the obstruction. Plant the seed from one and one-half to two inches deep. As to the precise time when to apply water, if at all, to these corn or cane crops, one should be governed entirely by circumstances. Whenever a tendency is seen to droop and wither on the part of the growth, and the cultivator does not correct this it is pretty safe to water. The usual time is when the silk is beginning to form or the seed in the cane to develop. In some instances from three to four irrigations are given, but this is quite uncommon.

Several non-sacharine sorghums are well worthy of extended cultivation. Among the most valuable of these are Kaffir corn, Millo maize and Large African millet. These are chiefly valuable for fodder purposes, and either green or when properly cured, are greatly relished by stock. The soil, cultivation and irrigation required are similar to corn. One of the chief essentials to success with these is to have the soil, in advance of planting, in prime condition. When grown as a forage plant, irrigation is seldom required, but planting should usually be done early in the season. For fodder purposes rye and oats are sown both in fall and spring, and where soil is well prepared in advance of sowing they do not need irrigation.

THE FIELD PEA.

This is often a most valuable plant both for grain and forage. For best results the soil should be rich and mellow and rather moist, although this crop will do very well on any average soil. Plant early in the spring with drill and at the rate of a bushel or perhaps a little more, if for grain, and if for forage from one and one-half to two bushels per acre. Harvest for forage when the plant is in full bloom, and for grain as soon as it begins to ripen and before the vine is too dry.

Two crops may often be grown for forage under irrigation. The field pea when ground is excellent feed either for cows or for swine, and is more valuable than corn, and the yield per acre is fully as great. Two irrigations are generally required for grain and one for fodder.

TOBACCO.

The finest leaf is raised on light, rich, warm soils, but the average upland soil of Colorado is thought to be well adapted to its growth.

Grow plants in seed bed and plant in open ground the last of May, in rows three feet by two feet apart.

If coarse growing kinds are grown, more room than this will be needed. Let the water follow the planting. Begin cultivation at once after plants are set out. Stir the soil close up to them frequently until the plants are two to two and a half feet high and ready for topping. With thorough cultivation one irrigation is usually sufficient for tobacco.

Strong plants set in May in this latitude will usually be ready to cut early in September. But when mature the leaf will stand the frosts of September without injury.

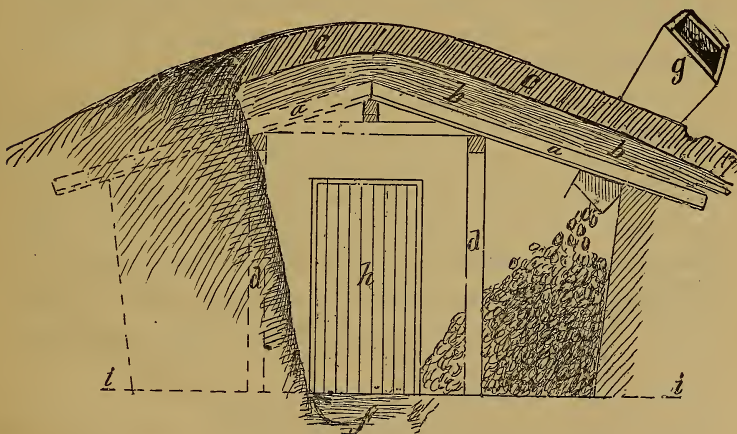
The various operations of priming, (which consists of removing all the lower leaves near the ground,) topping, (which is the removal of the flower stalks when large enough to be taken out,) of suckering, (the purpose of which is to confine the plant to the growth and quick maturity of a certain number of leaves,) all require attention during the growing season. Likewise injurious insects must be watched, and the right development and consequent value of the crop, will depend on the care and promptness with which these various processes are attended to. This is likewise true of the matter of curing, stripping, bulking and packing. But the details of these are beyond the province of this work.

The cost of producing one acre of tobacco last season at the Colorado State Agricultural College was found to be $78.50, and the quality produced was pronounced by experts to be equal to the best. Of the eighteen varieties tested there all fully matured.

THE POTATO.

Early and deep plowing are especially recommended for the best results with the potato, and a good, sandy loam with clayey sub-soil is found well adapted to the right development of the great tuber. Always select sound, smooth, well ripened seed for planting, and if large, cut twice in two, and the smaller ones once in two. Avoid cutting seed too small in a very dry climate, as it is liable to wither and become dried up before it has time to sprout. For the same reason never cut seed many days before planting as it is apt to become dry and worthless.

Mark the ground off in straight rows from three and one half to four feet apart. Drop the seed from fifteen to twenty inches apart in the rows. When the acreage to be put in is large use a two horse planter.



CONVENIENT POTATO CELLAR.

a, boards; *b*, straw; *c*, dirt; *d*, posts running lengthwise of cellar; *h*, door; *g*, shoot and ventilation; *i*, bottom of pit.

In regard to irrigation, all potato growers agree that the longer the vines can be kept growing without watering, the better for the crop, but when they begin to wither and turn yellow around the roots, turn on the water. Furrow the rows out with shovel plow with wings attached and make the channels so that the vines will not be flooded.

This is an important precaution, as permitting water to flow over on the vines is apt to ruin the crop. Two irrigations are generally sufficient and sometimes one, if applied at the right time. As soon as the soil becomes dried, so that it will not be sticky in working, and before it has time to bake, cultivate up loose and deeply.

By all means keep down the weeds.

The yield can be largely increased by trenching in well-rotted stable manure or by the use of artificial fertilizers, like bone meal, mixed with the soil in the bottom of the trench.*

BUCKWHEAT.

This crop succeeds well in portions of Colorado and the West. In fact it will often do well on soils where other cultivated crops fail. The demand will always be sufficient to justify quite extensive plantings. But enough should be sown to warrant its being milled, wherever grown. About the middle of June is the right time for putting in in Colorado. The silver hulled is the best for a general crop. It is a better yielder, matures earlier and is of finer quality than the common sorts.

The Japanese variety is worthy of extended trial, and wherever it succeeds is profitable. It is stated to mature earlier and produce more heavily than even the silver hulled. Buckwheat requires but little irrigation, and often none.

* For other hints in regard to potato culture, marketing, etc., see special chapter in "Horticulture by Irrigation."

PEANUTS.

Those who desire to grow peanuts as a farm crop will find them easy of culture, certain bearers and heavy yielders under fair conditions.

Warm sandy soil, moderately rich, is the best, and the seed may be put in in drills about three and one-half feet apart, or planted in hills so that the plants can be readily cultivated. Plant the latter part of April or early in May, either in pod or shelled, from two to four nuts in a hill, and about the same depth as corn.*

The peanut stands drouth exceedinly well and scarcely ever requires more than one irrigation, which may be given as the tubers are forming. But it may often be grown without any irrigation whatever. An ordinary yield is not far from 50 to 100 bushels to the acre and the demand is large and constantly increasing.

The Savatilla, a new variety, is claimed to be of great merit on account of extreme earliness in ripening, enormous productiveness and fine quality.

THE SUGAR BEET.

Within a few years a considerable interest has shown itself in the direction of sugar beet culture. Recent experiments have proven that several Western States are well adapted to the production of a superior quality of this beet, and it seems destined to become an important crop as soon as the problem of the necessary capital and manufacturing facilities can be solved. In other words, the

*Note.—It is better to have the seed shelled, but care should be taken not to break the skin of the meat, as this is often fatal to its germination.

present enormous expense required for a suitable reduction or diffusion plant, is almost a bar to the successful manufacturing of sugar from the beet except under the most favorable conditions.

Experiments with the sugar beet in Colorado in 1888 were highly satisfactory as to yield and quality, and in some instances an analysis showed a per cent. of sugar in advance of the California product, and about equal to the best yields of France.

At the Colorado Agricultural College the soil used was a clay loam, which had been in clover sod for three years previous and broken in the fall of 1887.

The plants were irrigated four times, cultivated six times and hoed twice. The varieties tested, and yield of sugar in pounds per ton of beets, and also the relative yield per acre, as computed from a careful chemical analysis, are shown in the following table:

VARIETY.	Tons Beets Per Acre.	Lbs. Sugar Per Ton of Beets.	Lbs. Sugar Per Acre.
Excelsior	29.04	190	5,517.60
Lane's Imperial	30.45	240	7,318.00
Vilmorin	25.09	227	5,695.43
Imperial Improved	24.15	176	4,250.40

The remark is here made that, as to what would be a suitable soil for the sugar beet, must be proven by analysis or actual tests. Any good, clayey loam might do for the stock or table beet, but be entirely lacking in the essentials for the sugar-producing article.

CONCLUSION.

A summary of the leading points of farm irrigation will show the following:

1. That results will always be in proportion to the manner in which the soil is prepared before planting, and the after cultivation.

2. That deep stirring of the soil and thorough culture lessens the requirements with respect to irrigation.

3. After land has once been subjected to irrigation, it will as a rule, with good culture, annually require less water, until the needs of the soil reach the minimum.

4 Land should never be irrigated simply because water is abundant.

5. All vegetable and hoed crops should be well cultivated as soon after irrigation as the soil is in a condition to work.

6. Grass lands and meadows should usually be watered after each cutting, and once early in the spring.

7. Irrigation should be *thorough*, especially with grain crops, but water should not be permitted to stand on any land beyond the requirements of vegetation.

8. Great saving in the use of water, and numerous other benefits, may be secured by adopting improved methods for receiving and applying water, and for discharg-it from the land, and likewise by observing the effects of irrigation on different soils and crops. But finally it should be understood that "the best system" of irrigation for the farms and broad acres of the West is yet to be perfected and applied.

WEIGHTS AND MEASURES, AMOUNT OF SEED SOWN TO ACRE, USUAL NUMBER OF IRRIGATIONS AND BEST SOIL FOR VARIOUS CROPS.*

KIND OF CROP.	LBS. PER BU.	NO. LBS. TO THE ACRE.	BEST SOIL FOR.	USUAL NO. OF IRRIGATIONS.
Alfalfa	60	15 to 30	Rich sandy loam.	2 to 4 times.
Red Clover............	60	12 to 15	“ “ “	2 “
White Clover.........	60	6 to 8	Average soil.	Once a week.
Alsike Clover	60	6 to 8	Deep and moist.	3 to 6 times.
Esparsette	28	40 to 70	Light, chalky, grav'ly & Limey	1 to 2 times, often none.
Timothy	45	20 to 25	Deep and moist.	2 to 4 “
Blue Gaass	14	30 to 40	Rich loam.	Once a week.
Red Top.................	14	30 to 40	Deep and moist.	2 to 4 times.
Orchard Grass........	14	20 to 30	Good average, rather moist.	2 to 3 “
Evergreen Millet...	28	50	“ “	2 to 3 “
German Millet	50	25 to 30	“ “	2 to 3 “
Common Millet.....	50	25 to 30	“ “	2 to 3 “
Hungarian Grass ..	48	25 to 30	“ “	2 to 3 “
Hemp	44	33 to 35	“ “	1 to 2 “
Flax	56	20 to 28	“ “	1 to 2 “
Amber Cane..	50	3 to 7	Sandy loam.	1 to 2 “
Buckwheat	52	26 to 52	Light, sandy.	1 to 2 “
Corn......................	56	30 to 50 (in hills 6 to 9)	Sandy loam, warm.	Once.
Broom Corn...........	46		Same as corn.	“
Barley	48	96	Heavy clayey loam.	“
Rye........................	56	75 to 90	“ “ “	“
Oats	32	30 to 75	Rich loam.	2 to 3 times.
Wheat	60	60 to 90	Sandy “	2 “
Peas	60	90 to 120	“ “	3 “
Potato		in cut tubers, 8 to 14 bu.	Loose, moist, deep loam, clayey subsoil.	1 to 3 “
Squash & Pumpkin	In hills	2 to 3	Warm, sandy, rather rich.	1 to 2 “
Musk Melon...........	“	2 to 3	“ “ “ “	1 to 2 “
Water Melon.........	“	3 to 4	“ “ “ “	1 to 2 “
Mangle Wurzel......		4 to 5	“ “ “ “	1 to 2 “
Russian Sunflower			“ “ very “	1 to 2 “
Tobacco........	....	1 oz. of seed for 5000 plants	Light, rich, warm.	1 to 2 “
Pea Nuts	....		Medium, warm.	1 to 3 “
Sugar Beets	....		Deep, clayey loam.	1 to 3 “

*It should be remembered that this table is only intended as a general guide so far as it refers to soils and irrigations, and is subject to modifications by reason of local conditions or surroundings.

Horticulture by Irrigation.

(ILLUSTRATED.)

BY A. E. GIPSON, EX-PRESIDENT OF THE COLORADO STATE HORTICULTURAL AND FORRESTRY ASSOCIATION.

A concise, practical treatise on Fruit, Vegetable, Forest tree and Ornamental Tree and Plant Culture, with a very complete list of fruits, forest trees and ornamentals for general planting west of the Missouri.

WHAT OTHERS SAY OF IT:

Brim full of information of value to the farmer and gardener, whether amateur or professional, which ought to assure its presence in the hands of every cultivator of the soil in the arid region.—Professor James Cassiday, Colorado Agricultural College.

A valuable book. It meets a serious want, and will prove invaluable to planters on the plains.—Prof. J. L. Budd, the Eminent Horticulturalist of Iowa.

I embrace the earliest opportunity of saying how greatly I esteem this book. .It is most admirably adapted to its purpose. I wish it might be placed in the hands of every fruit and forest tree grower in the Rocky Mountain region.—Col. E. T. Ensign, State Forest Commissioner of Colo.

" It is just what is needed. The best work of the kind out, and will supply a long felt want."—A. N. Hoag, "Good Luck Fruit Farm," Fort Collins, Colorado.

" A good thing, and those who follow closely the methods therein set forth, cannot go far wrong."—John Gravestock, Fruit Grower and Nurseryman, Canon City, Colorado.

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