Irrigating Field Crops in Montana

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## Table of Contents

1. Introduction .................................................. 3
2. Units of measurement ........................................ 4
3. Capacities and characteristics of soils .................. 5
4. Length of run .................................................. 7
5. Infiltration rate .............................................. 8
6. Use and water requirements of crops ..................... 8
7. Irrigation efficiency ......................................... 10
8. When to irrigate .............................................. 14
9. Alfalfa ......................................................... 15
   (a) Old stands for hay  
   (b) new stands  
   (c) Seed production  
10. Clover .......................................................... 19
11. Pasture ...................................................... 20
12. Mountain Meadows .......................................... 21
13. Small Grain .................................................. 23
14. Seed Peas .................................................... 24
15. Field Peas ................................................... 24
16. Field Beans ................................................. 24
17. Corn .......................................................... 26
18. Sugar Beets .................................................. 26
19. Potatoes ...................................................... 31

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Introduction

The purpose of this bulletin is to assist Montana farmers and ranchers in deciding when to irrigate and how much water to apply in the production of general field crops. Included are alfalfa pasture, wheat, oats, barley, corn, sugar beets, potatoes, seed peas, and field beans.

As more land is brought under irrigation the more important it becomes to make the best use of the water supply that is available for irrigation.

For the maximum production of quality crops there must be enough moisture in the soil for plant use continuously throughout the growing season.

The total amount of precipitation, plus irrigation required to produce a crop depends on the kind and amount of crop growth, its stage of growth, the soil and climatic conditions. More water is required in the hot dry climate and the longer growing season in the Plains Area than is required in the higher mountain valleys where the summer temperatures are cooler and the growing season is shorter.

Where water is plentiful and low in cost, water users frequently pay little attention to the amount applied. This often results in over-irrigation which is a waste of water and soil fertility. Too much water causes a reduction in crop yields. If continued over a period of years it will result in erosion, leaching of fertility, water logging of land, restricted soil aeration and accumulation of alkali at the surface. Reclamation of land where excessively irrigated is costly.

According to the 1950 Agricultural Irrigation Census, there were 189,497 acres of irrigated land in Montana described as being artificially drained and 182,614 acres of irrigated land in need of drainage. The total amount of irrigated land in Montana, according to the census in 1950 was 1,808,576 acres.

Where delivery is made to each farm by small streams of continuous flow, it is likely that more will be wasted by delivery on a demand or rotation basis than from a larger stream. Where there is no reservoir storage and water is diverted directly from mountain
streams having a large spring runoff but which go nearly dry in mid-summer, water users generally apply too much water early in the hope of making up for the expected short supply of water later in the summer.

This is not wise, because crops require less water during the cool days of early season, and the soil is usually already full of moisture.

However, some advantage can be taken of the early runoff by improved tillage methods that increase the water holding capacity of the soil and by increasing the fertility of the soil by applying-barnyard manure, or plowing under sweet clover. These practices make more efficient use of available moisture, increase the moisture holding capacity of the soil and bring bigger profits.

Excessive irrigation is like running water into a reservoir that is already full.

**Unit of Measurement**

To apply irrigation water according to the requirements of the various soils and crops, know the quantity of irrigation water being used, the storage capacity of the soil and the needs of the crop. Where the water is not already measured to the farm by the ditch company, a Parshall Flume, such as shown in Figure 1, may be installed for this purpose.
You measure flowing water in cubic feet per second, in miner’s inches, or in gallons per minute. A cubic foot per second stream will fill a box one foot square and one foot deep in one second. This is equivalent to 40 miner’s inches and also to 450 gallons per minute.

A stream of one cubic foot per second, (commonly abbreviated to second-foot or C.F.S.) flowing one hour, will cover one acre an inch deep; or briefly, a second foot equals one acre-inch each hour. An acre-inch is also equal to an inch of rainfall falling on one acre.

A single irrigation adds from 2 to 6 or more inches of water to the soil. The total amount of irrigation water applied to a crop during the irrigation season is expressed in either acre inches or in acre feet (i.e., three 5-inch irrigations would equal 15 inches or 1.25 acre feet).

**Capacities and Characteristics of Soils**

Perhaps the greatest single factor influencing irrigation on any farm is the soil. The soil acts as a reservoir in which water is stored between irrigations, for the use of the plants. While soils on different farms vary in their capacity to store water for plant use, the soil on any individual field or farm has rather fixed irrigation properties. Once these properties are determined, use them as a guide in irrigation, regardless of changes in crops and irrigation methods. These factors are:

- Texture or size of soil particles.
- Depth soil moisture storage zone or water table.
- Character of subsoil, whether hardpan or porous sand and gravel. Moisture storing capacity depends upon the depth of soil and upon the presence of hardpan, porous subsoils or a high water table within reach of plant roots. Moisture storing capacity also depends upon the texture and structure of the soil as well as its organic matter content. Use the soil auger shown in Figure 8 to obtain more information about your soils.

Light textured soils without heavy subsoil or high water table can store for plant use from 0.6 to 0.75 inches of water for each foot depth of soil from a single irrigation. General crops use moisture from such soils from depths of 4 to 6 feet. From 3 to 5 inches of water may be stored in such soils from each irrigation.
Figure 2. A clay loam soil profile of the kind shown here will store 2" of water or more per foot of soil. The depth of soil is below the root zone of crops.

For soils of medium texture, from 1 to 2 inches of water may be added and retained per foot depth of soil. Where heavy subsoil or ground water does not interfere with water movement, you can apply as much as 6 inches of water in a single irrigation for plant use since irrigation water penetrates such soils readily.

It is difficult because of slow penetration to get moisture deeper than 1 foot in heavy clay soils during a single irrigation, without danger of drowning out the crop. Occasionally, it will penetrate as deeply as 3 feet. The total water stored in heavy clay soils may vary from 1 to 3 inches from each irrigation. For clay loam soils of uniform texture, moisture penetrates readily to 3 to 6 feet per irrigation.

The average depth of water, useful to plants that can be stored in the upper 3 to 6 feet of heavy soils varies from 1.5 to 2.0 inches per foot depth. Total water per irrigation on clay loams may vary from 4 to 6 inches.

The storage capacity per foot depth of coarse-grained soils, such as gravels and sands, is not as great as the clays and loams. Capillary attraction holds moisture in the soil as a thin film of water, which clings to the surface of each soil particle. Since there is comparatively much more surface exposed in fine grained soils, the amount of water which can be stored is also correspondingly greater.
Fine-grained soils several feet deep may be slow to fill, but when filled they store a large amount of water. Coarse grained soils, such as sands and gravels, provide little storage as shown in Figure 4, medium textured soils exceed both light and heavy soils in total storage capacity of moisture readily available to crop roots.

**Length of Run**

On the lighter more open soils, (sands and gravels,) it is advisable to make light frequent irrigations. Make short runs and use streams as large as can be handled properly to wet the soils rapidly without causing erosion. Use longer runs on clay soils and lengthen the time between irrigations. Extremely heavy soils may also require frequent applications because of their slow rate of water absorption. This sometimes makes it impractical to saturate the entire root zone with one irrigation.

Space ditches so the field will receive a uniform application of water required, with the least time, labor and water.

Short runs require more ditches, but will save water.

Long runs require fewer ditches, but causes uneven application, and waste of water.

**WASTE OF WATER WITH TOO FEW HEAD DITCHES**

![Diagram showing water waste and saving with different lengths of runs](Image)

Figure 3. The upper diagram shows how water is wasted by a run that is too long. Near the head ditch the water has penetrated twice as deeply as necessary. The lower diagram indicates the saving in time and water by cutting the run in half.
Length of run, long or short, has not affected yields.

After a period of years in poor drainage, excessively long runs, often associated with over-use of water may cause lack of proper soil aeration and the leeching of soil nutrients.

It takes longer to irrigate a field by long runs than by short ones. This is important from the labor standpoint. Also in times of drought a delay of a few days in applying water may cause stunted growth.

Guide for Proper Length of Run: Length of run is correct when the largest non-erosive stream reaches the end of the furrow in ¼ of the time the water needs for adequate penetration. After the water runs to the end of the furrows cut it back to avoid waste. This guide doesn’t apply on slopes less than 2 percent. On flat slopes, stream flow may not have to be cut back at all.

Infiltration Rate

Most farmers know whether the soil takes water very fast, very slow, or somewhere in between. This is the infiltration rate. It is important to know the infiltration rate. How many inches deep will water penetrate in a given length of time? You can determine this by checking the length of time of irrigation, and the depth of penetration. After you make several of these tests, you will know the infiltration rate. Then you can make a definite schedule for water change. This will help to assure more uniform penetration to the proper depth.

Use and Water Requirements of Crops

You can figure the daily and monthly requirements for various crops and soil conditions in any locality if you know the climatological factors. The necessary information, data and explanations are in Montana Agricultural Experiment Station Bulletin 494, by Monson, Cridge and Davis. This information makes it possible to more accurately plan the irrigation system to meet peak demand for one farm or many, using either sprinkler or gravity system. Consult this bulletin before planning new projects.

If you already have an irrigation system installed and operating, usually it is possible to increase efficiency, save labor, save water or do a better job of meeting the peak demand of the crops.

The amount of water Montana crops use daily will range from .17 inches to .27 inches, during the period of most rapid growth, and average about .22. You can figure a maximum withdrawal or use of about ¼ inch per day, and be safe most of the time for Montana
crops, and conditions. For certain crops, seasons and conditions, the use may be much higher or lower, but this figure is a practical and workable one to keep in mind.

**Figure 4. Method of determining the amount of water to apply to various crops on various soils.**

Normal depth irrigation should penetrate for crops

Soil Moisture holding capacity, in inches, to be supplied per irrigation.

- Peas
- Beans
- Corn
- Clovers
- Potatoes
- Small Grain
- Pasture
- Sugar Beets
- Alfalfa

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Peas</th>
<th>Beans</th>
<th>Corn</th>
<th>Clovers</th>
<th>Potatoes</th>
<th>Small Grain</th>
<th>Pasture</th>
<th>Sugar Beets</th>
<th>Alfalfa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium to Fine Textured Soil</td>
<td>2&quot;</td>
<td>3&quot;</td>
<td>4&quot;</td>
<td>5&quot;</td>
<td>6&quot;</td>
<td>7&quot;</td>
<td>8&quot;</td>
<td>9&quot;</td>
<td>10&quot;</td>
</tr>
<tr>
<td>Sandy Loams</td>
<td>3&quot;</td>
<td>4&quot;</td>
<td>5&quot;</td>
<td>6&quot;</td>
<td>7&quot;</td>
<td>8&quot;</td>
<td>9&quot;</td>
<td>10&quot;</td>
<td>11&quot;</td>
</tr>
<tr>
<td>Sand</td>
<td>4&quot;</td>
<td>5&quot;</td>
<td>6&quot;</td>
<td>7&quot;</td>
<td>8&quot;</td>
<td>9&quot;</td>
<td>10&quot;</td>
<td>11&quot;</td>
<td>12&quot;</td>
</tr>
</tbody>
</table>

Depth of Crop Root Zone
Or
Depth of Soil to Gravel
Or
Depth to Adequate Moisture
Therefore, if you have a soil that will store 2" of water, you may have to irrigate as often as every eight days, or even oftener. The less water the soil holds, the higher is the percent lost by evaporation. A soil with 4" capacity would hold for about 16 days with no irrigation, and a 6" capacity soil may not require irrigation any oftener than 24 days. This, of course, assumes that the soil is filled to capacity with each irrigation.

In order to estimate the capacity of your soil to store water, you need to know the average depth of the soil to gravel, or the depth of the crop root zone, which ever is less. On Figure 4, select the soil root zone depth figure for the crop you will be growing, or the actual depth of your soil to gravel, if it is less than the root zone depth. Follow the chart up vertically, until you intersect the line which best describes your soil. Maybe your soil will be in between two of these major types. If so, stop in between.

When you strike the soil type line, turn left and move on the horizontal line. The figure you intersect on the left side vertical scale is the approximate number of inches of available water your soil can store.

Irrigation Efficiency

If you are unable to cover your land before the water stored in the soil is all used, you will need to make some changes. When the weather helps out, everything is lovely. But when it is really dry and hot for a long period that's when irrigation pays-off. If your irrigation system is not capable of doing the whole job in Montana, it's only partly effective.

Suppose you are growing small grain and alfalfa, and your soil is 2½ feet deep, to gravel. Let's also suppose your soil is between the sandy loam and clay loam type. By referring to Figure 4 you can see that you can store about 4" of water in the 2½ foot root zone.

Your 4-inch irrigation will last about 16 days. If you have 100 miner's inches of water, or 2½ c.f.s., and irrigate 5 acres per day, you can cover 80 acres in 16 days. Suppose you have 160 acres. It will take 32 days to irrigate. Refer to Figure 5. Now divide the acres per day irrigated by the stream flow, and you will get 5:/2½ = 2 acres per day, per c.f.s.

Place the pencil on 2 at the base line, Figure 5, and move up until you reach the 4 inches root zone capacity. Then turn left on the horizontal to the efficiency scale. You will find your efficiency to be 33 1/3 percent. Since the efficiency is very low, all you need to do is double the efficiency and you can irrigate 4 acres per day.
per c.f.s., applying 4 inches. On the 160-acre farm you could then irrigate 10 acres per day, or the whole farm in 16 days, if necessary, during the peak use.

By using Figure 4, you can quickly estimate the water holding capacity of your soil. From there go to Figure 5, and determine the percent efficiency for your irrigation system, provided you know the amount of water you use, and how many acres per day you irrigate.

**Figure 5. Method of determining irrigation efficiency on a field or farm.**

\[
\frac{\text{Acres irrigated per C. F. S. in 24 hrs.}}{\text{Size of stream in C. F. S.}} = \frac{\text{Acres irrigated per 24 hr. day}}{\text{A. per C. F. S. per day}}
\]
Let's take another problem. Suppose you have 320 acres in the field, and you are using 6 c.f.s. of water. Now suppose when you finish one field, you averaged 13 acres per day. Let's also say your soil is 6 feet deep or more, and is heavy clay type. The crop is alfalfa. From figure 4, we find that alfalfa can use moisture effectively to a depth of 5 feet, but experience has shown that it takes so long to wait for 5 feet penetration, that it is not practical on this heavy clay soil.

In addition to this, you have taken an auger or spade and found by digging in several places that only the top two feet of soil are dry. This means you will only attempt to fill the top two feet. By consulting Figure 4 again you find 2 feet at the bottom, and follow up the line to the fine textured soil. When you strike this line, go to the left horizontally, and find you have about 4 inches of storage capacity in these two feet of soil.

Now look at Figure 5. You are using 6 c.f.s. of water, and irrigating 13 acres per day. This means 13÷6=2.2 acres per c.f.s. per day. You apply 4 inches of water, so you place your pencil at the bottom of Figure 5, on 2.2, and then move straight up,
until you intersect the 4-inch root zone line. From there, go left on the horizontal line to intersect the efficiency line at about 37%.

Now suppose you want to try to increase the efficiency to about 60%. Place the pencil on the left side efficiency scale, at 60%. Move to the right to intersect the 4-inch root zone line, then straight down to the bottom. Now you find you must cover about 4.3 acres per c.f.s. of water, or 25.8 acres per day for 6 c.f.s. of water.

There are many ways to increase irrigation efficiency. Increasing the man hours per day spent with the water could double the efficiency. Maybe the method of application must be changed. Possibly the ditches need revision, cleaning, enlarging or relocation. Determine the cause and correct. Increased efficiency saves labor on a per acre basis. It saves water, makes it available for more land, or more irrigations per season. It may even double the yield.

Figure 7: This alfalfa field with alkali on the surface is usually the result of careless use of water.
**When to Irrigate**

Figure 8. Use of the soil auger will give the moisture condition in each foot of soil in the root zone. Sample each foot of soil and use the chart in figure 9 as guides for irrigation.

### INTERPRETATION OF SOIL MOISTURE
**(FOR MEDIUM TEXTURES)**

<table>
<thead>
<tr>
<th>DEGREE OF MOISTURE</th>
<th>FEEL OR APPEARANCE</th>
<th>AMOUNT AVAILABLE MOISTURE REMAINING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>Powder dry</td>
<td>None</td>
</tr>
<tr>
<td>Fair</td>
<td>Somewhat crumbly but 1/2 or less will not hold together.</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>Forms a ball, will &quot;slick&quot; slightly with pressure. 1/2 to 3/4</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>Forms a ball and is pliable, &quot;slicks&quot; readily 3/4 to field capacity</td>
<td></td>
</tr>
<tr>
<td>Wet</td>
<td>Free water can be squeezed out. Above field capacity</td>
<td></td>
</tr>
</tbody>
</table>

Figure 9. When moisture content of the soil drops below 50%, irrigate rather soon and complete before plants show visible effects of drought.
Figure 10. Optimum plant growth takes place when the right amount of
moisture is available, and drops sharply when the soil is too dry or too wet.

Probably the greatest difficulty in the timing and amount of
irrigation is that very few people take the trouble to find out about
the moisture below plow depth. Figure 9 will help to interpret the
amount of moisture available in the soil by the squeeze test. The
soil auger will make it possible to take samples of soil from each
foot of soil.

**ALFALFA**

There are several methods of irrigating alfalfa. These include
sprinkling, flooding, borders and corrugations.

For maximum hay production, keep alfalfa well supplied with
moisture throughout the growing season. Lack of moisture delays
growth and reduces yield. Where you get two to three cuttings,
yields generally increase as the amount of irrigation water is in­
creased up to 30 inches per season. Yields rarely justify applica·
tions of more than 30 inches.

The number of irrigations needed depends upon the nature of
the climate and soils in the locality. In warmer areas in Montana...
with longer growing seasons and a normal of three cuttings, apply one to two irrigations per cutting. In inter-mountain valleys with cool, short growing seasons, apply only one irrigation to each of two cuttings, that are normally expected.

The soil is often given too much or too little water, or it is saturated with cold water early in the spring, just because water is plentiful. At that time it needs only heat and air. Delay the first irrigation in the spring until the soil warms up enough for active growth to take place. If the soil is well supplied with moisture in the spring and there are heavy May and June rains, no irrigation may be needed until after the first crop is removed. Alfalfa should usually receive an irrigation after the last crop of the season has been removed.

While alfalfa can make use of heavier irrigations than most crops, due to its deeper root system, little increase in yield is received by applying more than six inches of water at a single irrigation, regardless of soil type.

![Figure 11. From Scotts Bluff, Nebr. Exp. Station.](image-url)
DISTRIBUTION OF ALFALFA ROOTS WITH A WATER TABLE THREE FEET BELOW GROUND SURFACE

<table>
<thead>
<tr>
<th>DEPTH IN FEET</th>
<th>% ROOTS</th>
<th>SOIL TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>51.10</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>46.56</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2.04</td>
<td>SAND</td>
</tr>
<tr>
<td>4</td>
<td>0.30</td>
<td></td>
</tr>
</tbody>
</table>

Unfavorable root growth for alfalfa

Figure 12. From Scotts Bluff, Nebr., Exp. Station.

Figure 13. The spots on this alfalfa field which did not get water produced no second cutting.
A six-inch irrigation is considered a heavy application and is justified only on deep, well drained medium textured soils.

Alfalfa on soils of fine texture requires more frequent irrigations with medium depths of 3 to 4 inches for each application. For shallow, coarse textured soils, light irrigations of 2 to 3 inches, every 8 to 10 days may be necessary during the warmer part of the season.

The tendency is to irrigate too lightly with sprinkler systems. There are many instances where serious reductions in yield resulted from putting on 2 to 3 inches, when 4 to 6 should have been applied. Under-irrigation is not so likely by surface methods, but un-uniform irrigation is very common. Irrigate uniformly, according to soil storage capacity, depth of root zone and plant needs.

New Alfalfa

Have enough moisture in the soil at planting time to germinate the seed. Keep the small plants growing rapidly until they are three or four inches high, before the first irrigation. This requires a well prepared seedbed, that is firm and adequately supplied with moisture.

For spring seeding, this may be met by fall plowing and fall seed bed preparation. Where alfalfa is to follow sugar beets, beans or potatoes, prepare a good seedbed by surface working after harvest, without plowing.

New seedings of alfalfa, particularly when planted with a nurse crop, need earlier and more frequent irrigations than do older stands of alfalfa, or small grains planted alone. Many stands are lost by allowing the surface to get dry while the nurse crop is getting ripe and being harvested.

Seed Production

The water requirements for alfalfa seed production are only slightly different than for hay. On heavy deep soils, irrigate in the fall and early spring. For maximum production, the plant must have adequate moisture early to carry it into the peak of the growing season, in a vigorous condition. On deep, medium to fine textured soils, one early heavy irrigation will be all that is needed most years, if the first crop is for seed. On sandy soils, or shallow soils, irrigate lightly and frequently.

It is generally best to avoid irrigation in the bloom stage. An irrigation prior to bloom and one after the pods are first formed, if
needed, will increase yields. It is probably best not to irrigate more than once in the pod stage.

Where the second crop is saved for seed, harvest the first crop early to allow more time for the second crop to mature. A heavy irrigation, following the first cutting is probably in order. Follow the same procedure in bringing the second crop to maturity, as already recommended for the first cutting. Don't irrigate excessively while the plant is growing, but don't let the plants burn or suffer, either.

**Clover**

There are several kinds of clover, which have a wide variety of rooting habits. Sweet clover and red clover root down to about 5 feet or more, and will use moisture in the root zone from 3 to 5 feet deep. Generally speaking, clovers are like alfalfa, in that they can use heavy applications of water at the beginning of the growing season, and also when the next crop is starting. Some of the clovers like dutch, ladino and alsike have a shallower root system, and require more frequent irrigation.

When you grow clovers in mixtures of grasses and legumes, govern the irrigation by the average root zone, with special emphasis on keeping moisture available in the top two feet of soil. For starting new stands and producing seed, the same general principles apply as were described under alfalfa.

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**Figure 14.** Irrigated pastures provide excellent returns when properly irrigated and managed.
Pasture

Irrigated pastures are usually a combination of several kinds of grasses and legumes. There are at least one grass and one legume in most pasture mixtures. This means that the variation in root zone depth must be taken into account in irrigation. If alfalfa, sweet clover, or red clover is in the mixture, give one or two heavy irrigations during the season. These could be in early spring and midseason, or midseason and fall for next year's use on heavy soils. The balance of the season, light and frequent irrigation to keep the top soil moist are very important.

If all of the grasses and legumes are shallow rooted, then irrigate lightly and frequently throughout the season. Spacing in time and amount will depend on the soil type. Use pasture rotations so they will correspond with the frequency of irrigation. Then you can irrigate as soon as the stock are taken off, or rotated to another field.

The border dike method of irrigation is excellent for pastures. This is true, because close spacing of dikes for steeper and rougher ground can be tolerated in pasture. Adopt the method of water application which will give the greatest efficiency, since the job of irrigation will have to be done more often than with other crops.

Furthermore, if many dikes, ditches or corrugations are required to make irrigation easy and efficient, the livestock won't mind and you won't have to ride much equipment over these structures.

Figure 15. The wheel-move sprinkler has worked well and saves time in moving for irrigation of pasture and hay lands.
Mountain Meadows

Native hay land on the high valleys, that receives additional moisture either from irrigation, underground water or flood water is called mountain meadows. The type of vegetation which is common to these meadows is largely dependent on the soil moisture situations. In some areas the practice is to turn the water out on these meadows in the spring, spread it out so most of the land is continuously wet and leave it like this until the land is dried up for harvest. In other cases, underground water keeps the free water table in the soil at or within a few inches of the surface.

In either case, the plants which can grow must be water loving or wet land plants. Some of the sedges, wire grass, red top and several other grasses do well under these circumstances. They do not produce a great abundance of forage. Very seldom do legumes show up in these mixtures.

If you are not satisfied with about one ton or less per acre of hay, and some grazing, there are two or three alternatives to increase production.

1. You may continue the same practice of irrigation, and use a nitrogen fertilizer. An application of at least 250 lbs. of 20-0-0 or 150 lbs. of 33-0-0 fertilizer would seem to be about right. This will usually increase yields enough to pay for the fertilizer. The increase will be most evident the year of application, but may have some carry-over under certain soil conditions.

2. If the meadow is high water table land, you can drain it. After that, irrigate frequently, or place controls in the drain ditch, so sub-surface irrigation can be somewhat controlled. This has worked quite well in many instances.

If the land is drained, then irrigate by surface methods. It is usually best to plow up the land and plant new crops if the soil can be worked. If this is not done, a decrease in yield is apt to occur in the original forage stand. The wet land plants will not produce to the maximum under intermittent irrigation. Unless you are willing to invest more money per acre in labor, seed and farming operations to increase yields, you are better off to continue the present practice.

There appears to be little need to change irrigation methods without changing the crops and cropping practices. Likewise, it would be futile to try to change vegetative cover without changing the water application practice. The kind of irrigation you practice will, over a period of years, de-
termine the kind of vegetative cover you get or can keep.

There are many factors to consider before attempting a changeover. In any case, it is wise to do a small amount at a time, to gain experience and to avoid large investments which might not prove to be what is wanted. Some of the wettest spots could be drained a little each year. Some of the dryer places could be broken up, worked and reseeded. After reseeding to hay mixture or alfalfa, give regular, intermittent irrigations. This would provide a comparison with the old method.

Determine the kind of irrigation by the crop growing and the soil type. See alfalfa, clovers and pastures for more details.

(3) The Colorado Agricultural Experiment Station has experimented with mountain meadows and found that intermittent irrigations combined with early cutting, and commercial fertilizer, improved both the quantity and quality of hay. Where water can be controlled, use intermittent irrigation where it can be done without endangering the plants from drought. Always remember that the type of crop, and the soil are the guides to irrigation. If you use continuous irrigation, you will grow water loving plants, and the yield will not be high.

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**SOIL DEPTHS FROM WHICH WATER IS TAKEN BY OATS**

![Figure 16. From Scotts Bluff, Nebr., Exp. Station.](image)
Small Grains

Small grain is a light user of water. The season of use is relatively short, and the total requirement is not great. From one to three irrigations are usually ample for all kinds of small grain, and most of the common soil conditions. Winter wheat takes advantage of more of the rainfall, and therefore requires somewhat less irrigation. Barley is not a heavy user of water. The best time to irrigate small grain, like all other crops, is when the soil becomes dry and the plant needs water. This is true up until the time the kernels have formed. From then on irrigation may decrease yield.

If you give three irrigations, apply the first when the plant is six to eight inches high, the second in the early boot stage and the third in the early bloom stage. If one or two irrigations only are given, apply between the 5 leaf stage and early bloom stage. Apply the first irrigation in the 5 leaf stage, or when the soil becomes dry.

![Diagram](image)

Figure 17. Water becomes more efficient when the soil fertility is kept high. This shows the effect on barley yield when various amounts of water are applied to the crop grown on two different levels of soil fertility.

(Tempest & Snelson, 1930, near Brooks, Alberta)
If the soil in the first foot of depth will not hold together in a ball when squeezed in the hand, it is time to irrigate.

In most of the medium soils a three-foot depth penetration of the irrigation water will be ample, since most of the roots feed above the three-foot level. Make the first irrigation rather light, if two or three are to be given. Grain will not stand over-irrigation, that is, water standing on it for a long time, or the soil continuously wet. The yield goes down under these conditions, because of lodging, diseases and other difficulties which are encouraged by dampness.

If the ground is so dry at planting time that germination is impossible, then irrigate before planting. Irrigating the crop up usually reduces yields. If it is necessary to irrigate up, the corrugation method will give the best results because less crusting will take place.

**Seed Peas**

Successful growing of field peas requires careful irrigation. The water requirement is lower than small grain and the crop matures early. If the ground does not have sufficient moisture at planting time for germination, irrigate prior to planting. After the peas come up, never allow them to suffer for water. Neither should the crop be soaked for long periods during an irrigation. Some authorities say never to allow the water to set in one place more than two hours.

At any rate, light and frequent irrigation will be in order. Make short runs and keep the irrigator with the water practically all of the time. Handle waste water so as to avoid over-irrigation in parts of the field.

Scalding after irrigation happens quite frequently when the soil has dried out too much, before water is applied. Scalding retards growth. Space irrigations so that a good one can be given in the bloom stage, if possible. Even though the water requirement of peas is small they cannot be grown on dry land where irrigation water is not available.

If there is danger of the irrigation water right running out in midsummer, plant an early variety of peas early to help to insure water for maturing the crop.

**Field Beans**

Field beans are grown, mostly in the Yellowstone and Clark
Fork valleys of eastern Montana. The climate, rainfall and soil conditions in some areas of Montana are such that dry beans yield fairly well on dry land. It is ordinarily considered an irrigated crop, however, and planted only on land which can be irrigated. Beans do well on sandy, loam and clay soils which have good natural drainage.

Like other crops, irrigate them when the soil becomes dry. Irrigation to a depth of one or two feet is usually sufficient. Like peas, it is important to irrigate frequently to prevent suffering. Very dark color and wilting definitely indicate a lack of moisture.

The most critical time for the growing bean crop is when the plants come into bloom. Give them ample water at this time. In many cases this will carry them on to maturity. Irrigation after blooming is seldom necessary and it may delay maturity.

Beans are usually grown in rows and irrigated by the row method. Determine carefully the length of run, so there will be no long waits for water to get to the end of the row. It is better to have the run too short than too long.

Figure 18. Siphon tubes to deliver irrigation water to rows of corn insures uniform distribution and regular flow.
Corn

Most of the corn grown in Montana is produced in the eastern counties. A high percentage of it is in dry land. Like small grain it is a crop that will produce well in parts of the state without irrigation. Irrigation, however, insures greater yields of both ears and forage. Corn is frequently grown under irrigation, particularly along the Yellowstone River Valley.

If the soil is dry at planting time, make shallow furrows beside the rows. As soon as the corn is planted, run small streams of water in the furrow to provide moisture for germination. Don’t flood, because crusting may result in a poor stand coming through. A sprinkler is ideal for irrigating crops up, because it causes the least crusting. Crusting is most serious on heavy soils.

The working root zone of corn is such that irrigation to a depth of 3½ feet is effective. Irrigation will probably do the most good at the time of tasseling. This does not mean that the crop should be allowed to dry out before then. It is always best to irrigate according to soil and crop needs during the early part of the season. Corn can use moisture effectively up to the time it has dented.

Don’t irrigate after August 15 in Montana. This hastens maturity and reduces danger of frost damage.

For irrigations, other than for germination, make furrows about 6” deep midway between rows. Do not flood the corn. Keep the water in the furrows.

Sugar Beets

Irrigate so the sugar beet will make its best growth daily, throughout the growing season. You can improve your irrigation practices after study of the following four considerations.

1. Rooting habits of the beet.
2. Amount of water it takes to grow a beet crop.
3. The rate which water infiltrates into the soil.
4. Amount of moisture the soil will hold.

Land Preparation.—Level land so the irrigation furrows will have a uniform slope throughout their length. This assures a more even application of water into the soil. On large fields with rough, uneven slopes it is often more desirable and economical to level the field into several planes.

By leveling in several planes, cost of leveling is reduced because soil is moved shorter distances. The distance the water has to run
is shorter, which is often more desirable than running water the
entire length of fields in extremely long rows. The slope of many
beet fields which is now slightly irregular can be made uniform with
a land plane without the need of other heavy equipment. Provide
surface drains at the lower end of the fields so that runoff water
doesn't back up and over-top the furrow.

On land with very little slope or where soil surfaces are some-
what uneven water may flood over the beet rows. Ridge planting
overcomes this in some areas. Alternate close and wide row spacing,
with a large furrow in the wide spacing also have corrected this
condition.

**Size of Furrow Stream.**—Turn the largest size of stream that is
non-erosive into each furrow. This, of course, will vary with the
degree of slope and the condition of the soil. After the stream nears
the lower end of the furrow cut it back, so the water can continue
to be absorbed into the soil, with a minimum of runoff, at the lower
end of the field.

The reason for this is that the rate which soils absorb water is
the greatest during the first 20 or 30 minutes after application. This
rate of absorption then levels off, and remains constant after the
surface 6 inches of soil is filled.

Contrary to the belief of many, increasing the size of furrow
stream in a bare V-type furrow does not increase the rate at which
water infiltrates into the soil very much. Observation indicates
that average depth and average velocity is more important than
size of stream used. By cutting down on the size of furrow stream,
after the water is near the lower end of the furrow, infiltration of
water continues at the same rate. This also reduces the amount
of runoff.

**Length of Run.**—Length of run trials conducted by the Montana
Agricultural Experiment Station in cooperation with the American
Beet Sugar Foundation have shown that irrigation water can be
saved by controlling the length of run. Length of run did not have
an effect on yield. Long runs, however, resulted in less uniform
application of water. More water was required than was justified
by the storage capacity of the soil.

Tillage and harvesting are often hampered by cross ditches and
short runs usually mean more labor in building and maintaining
head ditches and more sets for an irrigation. For these reasons
make runs as long as possible without causing excessive loss of
water, due to deep percolation and soil erosion at the upper end
of the row.
The additional labor required to put in cross ditches to make runs the proper length may be more than offset by the reduction in time that it takes to irrigate a field.

Figure 19. Siphon tubes and canvas dam for row irrigation of sugar beets.

Control of Furrow Streams.—To maintain the desired size of furrow stream requires that the water be evenly distributed and controlled as it enters the furrow.

Siphon tubes can be used to distribute water directly from the head ditch to the furrows. These are metal, rubber or plastic and come in various sizes. Two siphon tubes can be used in each furrow, and as the water nears the lower end of the furrow stream, cut it back by removing one of the tubes. This will prevent excessive runoff at the lower end of the furrows.

Gated surface pipe is made in light weight metal sections that can be coupled together and laid across the field. It can be used to replace cross ditches in a field. Small adjustable gates regulate the stream flow to each furrow. This pipe can be obtained with
the gates spaced to match the furrow spacing of the beet crop. With this portable pipe it is possible to replace several cross ditches in a field. This means that you can cultivate and harvest across several lengths of run. No cross ditches means less weeds and more beets will be growing in that space.

Equalizing ditches and spiles give better furrow stream control. If the slope of your head ditch is nearly flat, place the spiles in it, and you won’t need an equalizing ditch. Spiles are straight tubes of lath, metal, plastic, rubber or concrete. Canvas hose is also used to distribute water to the furrows. This hose is fitted with canvas outlet tubes that are spaced according to furrow widths. This hose can be rolled up after use and moved to other fields.

**Water Requirements.**—Experience has shown that five or six irrigations are usually sufficient to produce maximum yield of sugar beets. This is confirmed experimentally in Experiment Station Circular 205, published in June, 1954. If irrigation is required for germination of the beets, furrow at planting time, and irrigate immediately. Sprinkler irrigation is very good for irrigating beets up. The early irrigation may be very light, say two or three inches.

Step up irrigations later in the season, according to the capacity of the soil to hold water, and the depth to which moisture is required. Usually four or five inches of water per irrigation is enough. Many of the heavy sugar beet soils in Montana store and carry moisture the year round, below the two foot depth, if the soil can be filled to say, four feet depth at some time during the year. In this case,
there never is any need to wet more than the top 18" to 24" of soil during the growing season.

Other soils have a high water table that keeps the ground moist below the three foot depth. After the root taps this moisture zone, there may be no need for further irrigation. If the water table is too high, say two feet or less from the surface, the root zone will be cut off, and the beet yield will be reduced. This does not appear to be true with a four-foot water table, however.

![Soil Depths From Which Water is Taken by Beets](image)

Figure 21. (From Scotts Bluff, Nebr. Exp. Station)

Studies of sugar beet requirements at Huntley, Montana, are summarized in Montana Experiment Station Circular 205, entitled "Irrigation of Sugar Beets." This publication deals with high water table soil and well drained soil for growing beets.

There appears to be some question about how late in the fall to irrigate. The last irrigation will probably be determined by the time of harvest, and more than likely for the sole purpose of putting the soil and beets in the best condition for harvest. Discontinue irrigation about 8 days before harvest begins, to avoid muddy conditions during digging. Late irrigation may reduce sugar content, so from the standpoint of sugar production, may not be worth anything.
On the other hand, if it makes the harvest easier and improves the topping, it is no doubt worthwhile. The type of soil and moisture condition prior to beet harvest will be the determining factors, but is not likely that irrigation after August 15 will increase the pounds of sugar you get.

Figure 22. Proper irrigation is important, both for quality and yield of potatoes.

Potatoes

Generally speaking, potatoes are like most other crops, in that they must be irrigated when they need it. If the soil is dry at planting time, it may be necessary to irrigate for germination. From that time on, never let the soil dry out. If the plants suffer from lack of water the quality of the crop will be adversely affected.

If a shortage of water is expected for late irrigations, then make the early irrigations rather light. If you have a sprinkler system, its use throughout the season seems to improve the quality of potatoes. This is particularly true if compared with a surface flooding method, which is not the best.
Irrigate potatoes in rows and never flood them. With a surface method use a wide ridge and keep the water level in the furrow, just below the seed piece, for the best results. This prevents puddling the soil around the growing tubers. The potato does not have a deep root zone, so the moisture placed about two feet deep is most readily available.

Since the plant is a shallow feeder, it is important to keep the top foot of soil moist enough to promote continuous growth. Whenever the plants show a dark color it is time to irrigate. Use both the color and hand squeeze test as a guide to know when to irrigate.

Put on two to three inches of water with each irrigation, depending on the soil type. As much as 20 inches during the season can be used beneficially. Stop irrigation early enough to allow potatoes to dry out and mature for the harvest.
Summary

1. The best guide to irrigation is the needs of the crop. Adjust the amount and time of application to meet crop and seasonal requirements.

2. A thorough knowledge of soil characteristics, crop requirements and rate of crop use are necessary to do a good job of irrigation.

3. An efficient job of irrigation, coupled with proper timing will give maximum returns for the water used. Efficient irrigation will reduce seepage and erosion, save time and water, and increase yields over a long period of years. Learn how to find your irrigation efficiency and do it for each field you irrigate. This will show you whether or not you need to make changes in the method of application.

4. Learn and use the simple soil tests that show the available moisture in the root zone, to insure proper timing and rates of water application.

5. Make tests of infiltration and length of run, to insure efficient and uniform application of water.

6. Apply water through a sprinkler system on the same basic requirements as for surface flooding. The only reason for applying less water to a field with a sprinkler system is because the sprinkler may be more efficient.

7. The soil can be used as a storage reservoir for certain crops and fields. Irrigation immediately preceding or immediately following the active growing season will fill this reservoir. By making use of this storage, the requirement during the peak season of growth may be cut down materially.