Irrigating Field Crops in Montana

G. H. BINGHAM and O. W. MONSON
SUMMARY

1. The total amount of water needed to produce a crop depends on the kind and amount of crop grown, and the climate.

2. When to apply irrigation water and how much to apply at each irrigation depends on the crop, its stage of growth and the soil.

3. Over-irrigation is not only a waste of water often accompanied by reduced yields, but, if continued, may result in partial or complete loss of the use of the land because of soil erosion, leaching of fertility, water logging or the accumulation of alkali.

4. All irrigation water should be measured as it is delivered to the farm. It is also necessary to know the moisture storage capacity of the soil and the needs of individual crops.

5. The average depth of water readily available to plants that may be stored each foot depth of soil from a single irrigation varies widely as follows: light soils, 0.6 to 1.00 inches; medium soils, 1.00 to 1.25 inches; heavy soils 0.75 to 1.00 inches.

6. With most crops from 80 to 90 per cent of the total water used is taken from the upper three feet of soil.

7. The total depth of water that may be stored within reach of plant roots from each irrigation varies from 2 to 4½ inches on light soils; up to 6 inches on medium soils; from 4 to 6 inches on clay loams; and from 1 to 3 inches on very heavy clays.

8. Moisture requirements for annual crops are relatively light early in the season and increase as the plant develops.

9. Perennial crops such as alfalfa and pastures require rather uniform amounts of water throughout the growing season according to the depth of the root systems.

10. Frequent application of moderate amounts of water at each irrigation will usually result in good crop yields with a minimum waste of water.
Irrigating Field Crops In Montana

By
G. H. Bingham, Extension Irrigation Specialist
and O. W. Monson, Irrigation Engineer

Introduction

How to make the best use of the available water supply is a vital problem confronting irrigation farmers of Montana whether they are new settlers or have irrigated their lands for a lifetime. The problem becomes more acute as the amount of available water per acre decreases in proportion to the area of irrigated land. The increased number of farmers on old irrigated lands also adds to the problem. As the larger farms are broken up into smaller units, and as the cost of irrigation increases, a more intensified type of farming is required to produce a higher net income per acre. Each farmer must learn how to successfully irrigate a greater variety of crops than ever before.

This bulletin is written to assist Montana farmers in deciding when to irrigate and how much water to apply in the production of general field crops including alfalfa, pastures, wheat, oats, barley, corn, sugar beets, potatoes, seed peas and field beans.

Governing Factors

For profitable crop production there should be ample moisture in the soil for steady plant growth from the time of planting until the crop reaches maturity. The total amount of water needed to produce a crop and the time of the year when it is required depends on the kind and amount of crop grown, its stage of growth, the soil, and climatic conditions.

In the hot, dry climates and longer growing seasons of the plains of Montana, considerably more water is required than in the higher mountain valleys where the climate is more temperate and the growing season shorter.

Where water is plentiful and cheap there is a tendency on the part of the users to pay little attention to the amount of water applied. This often results in excessive irrigation. Over-irrigation is not only a waste of water often accompanied by reduced yields, but if continued may result in loss of the use of the land due to erosion of the soil, leaching of fertility, water logging the land, or the accumulation of alkali at the surface.
Where delivery is made to each farm by small streams of continuous flow, there is a likelihood of greater waste, than if delivery on a demand or rotation basis is followed and larger streams are supplied. Where no reservoir storage exists and water is diverted direct from mountain streams having a surplus during spring run-off, but which go nearly dry in summer, farmers tend to apply excessive amounts of water early in the hope of making up for later shortages. Not only do crops need less water at this time than later in the season, but the soil is already nearly full of moisture. Excessive irrigation is like running water into a reservoir that is already full.

Units of Measurement

In order to apply irrigation water according to the requirements of the various soils and crops, it is necessary to know the quantity of irrigation water being used as well as 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 simple weir such as shown in Fig. 1, may be installed for this purpose.

Flowing water is measured in cubic feet per second, in miner's inches, or in gallons per minute. A cubic foot per second is a stream sufficient to 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 supplies enough water to cover an 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 an acre.

Fig. 1—Single wall rectangular weir.
A single irrigation may add from 2 to 6 inches or more 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.

The Soil

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 they may be used indefinitely as a guide in irrigation practices regardless of changes in crops and irrigation methods. These factors are:

Texture or size of soil particles.

Depth of surface soil to subsoil or water table.

Character of subsoil, whether hardpan or porous sand and gravel.

The moisture storing capacity depends upon the texture of the soil, the depth, and the presence of hardpan, porous subsoils, or high water table within reach of plant roots. This information may be obtained by the use of the soil auger shown in Fig. 2.
Moisture Storing Capacities of Soils

Light textured soils without heavy subsoil or high water table can store for plant use from 0.6 to 0.75 inches depth of water.

**Average Inches Depth of Water per Foot Depth of Soil for Depths of Principal Use of Soil by Plant Roots**

Fig. 3—Readily Available Moisture Storing Capacity of Soils.
each foot depth of soil from a single irrigation. General crops may use moisture from such soils from depths of 4 to 6 feet. From 3 to 5 inches depth of water may be stored in such soils from each irrigation.

For soils of medium texture, from 1 to 1.25 inches depth of water may be added and retained per foot depth of soil where heavy subsoil or ground water does not interfere with water movement. As much as 6 inches total depth of water may be added in a single irrigation to such soils for plant use since irrigation water penetrates 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 depths of 3 to 6 feet per irrigation. The average depth of water, useful to plants that may be stored in the upper 3 to 6 feet of heavy soils varies from 0.75 to 1.0 inch per foot depth. Totals 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, because of the small proportion of pore space between the coarse soil particles. Fine-grained soils several feet deep may be slow to fill, but when filled store a large amount of water. Coarse grained soils, such as sands and gravels, provide little storage as shown in Figure 3, medium textured soils exceed both light and heavy soils in total storage capacity of moisture readily available to crop roots.

On the lighter and more open soils, (sands and gravels) it is advisable to make light, frequent irrigations. Runs should be short and streams as large as can be handled properly to wet the soils rapidly. With medium to heavy soils, runs may be longer and applications heavier but less frequent. Extremely heavy soils may also require frequent applications, because of their slow water absorbing properties.

Root Development and Seasonal Demand

From 80 to 90 per cent of the total water used is taken from the upper 3 feet of soil by most crops. The relationship between amount of water absorbed by the roots at different depths and the total seasonal water requirements of four typical crops is shown in Fig. 4. In the irrigation of shallow-rooted crops such as sugar beets and small grains, the upper 2 to 3 feet of soil should be filled with water by each irrigation. There will then be suf-
Fig. 4—Seasonal use of water and per cent used from different depths by some field crops. (p. 14, Journ. Am. Soc. Agric. Eng., January, 1938. Courtesy author Leslie Bowen, Assistant Irrig. Eng., Bureau Agr. Eng., U. S. D. A.)
Efficient down drainage from the upper layers to supply plant needs at lower depths. With deep rooted plants such as alfalfa this depth may be increased to 4 to 5 feet.

Heavy irrigation on soils with good sub-soil drainage not only fails to produce increased yields but may reduce soil fertility by leaching the available plant food such as nitrates. With poor sub-soil drainage, heavy irrigations cause a rise in the water table which may eventually result in total loss of the use of the land because of water-logging or the accumulation of harmful amounts of alkali at or near the surface. The soil moisture prober shown in Fig. 5 is helpful to determine the depth in the soil to which moisture has penetrated during or just after irrigation. With a little pressure the probe can be pushed through moist soil, but cannot be pushed through dry soil.

Moisture requirements for annual crops are relatively light early in the season and tend to increase as the plant grows in size as indicated in Fig. 4.

Perennial crops such as alfalfa and pastures require rather uniform amounts of water throughout the growing season according to the depth of the root system.

**Measuring Efficiency of Irrigation**

Part of the water applied to land may be lost as surface run-off. Part of that which enters the soil, may evaporate directly from the soil, and a part may percolate through the soil below the reach of plant roots. The remainder of the water applied is held in the soil within reach of the plant roots and is available for direct use by the growing crop. The proportion of the total water applied to the soil that is used directly by the growing crop is the measure of efficiency of irrigation practice. Even under favorable conditions, all losses cannot be avoided yet present practices leave much room for improvement.
On coarse soils, where it is difficult to prevent excessive deep percolation, surface waste is easily prevented and soil moisture evaporation is less than average. On heavy soils where surface waste and evaporation may be large, deep percolation loss may be very small. Under the best conditions from two-thirds to three-fourths of the water applied is actually used by the plants. With unfavorable soil conditions or careless irrigation practices the crop may use less than one-third of the total water applied to the land. Generally about one-half the water delivered to the land from irrigation systems is used by the plants.

Where the losses are excessive, yields are reduced and it will pay to improve the methods used and reduce the losses. This may include grading and land leveling as well as recasting the entire farm irrigation system. Frequent application of moderate amounts of water at each irrigation will usually result in good crop yields, with the least waste.

**Alfalfa**

If alfalfa is to produce a maximum tonnage of hay it should be well supplied with moisture throughout the growing season. Lack of moisture will delay the growth and reduce the yield. Where 2 to 3 cuttings are obtained, the yields of alfalfa hay generally increase rapidly as the irrigation water is increased up to about

![Figure 6—Irrigating third crop alfalfa.](image)
30 inches a season. Beyond 30 inches the yield increase is too small to justify the use of much additional water.

The number of irrigations needed depends upon the number of cuttings, depth and nature of the soil and the climate of the locality. Where irrigation water is available throughout the summer, the number of cuttings obtained depends on the length of the growing season. For deep, medium textured soils with good water holding capacity, one irrigation for each cutting may be all that is needed. Alfalfa on well drained sandy or gravelly soils may require two irrigations for each cutting.

The soil is often given too much or too little water, or else it is saturated with cold water early in the spring, just because water is plentiful, at a time when it needs only heat and air. The first irrigation in the spring should be delayed until the soil warms up enough for active growth to take place. If the soil is well supplied with moisture in the spring followed by 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.

At higher elevations where two cuttings are common, the number of irrigations each season may vary from one to three for heavier soils, and from two to five on the lighter soils, depending on the season. At lower elevations, where three cuttings are obtained, the number of irrigations varies from two or three for heavier soils during seasons of ample rainfall, to six or seven irrigations for lighter soils during relatively dry seasons.

While alfalfa can make use of heavier irrigations than most crops, due to its deeper root system, little increase in yield is realized by applying more than 6 inches of water from a single irrigation regardless of the soil type. A 6-inch irrigation is considered a heavy application and is justified only on deep, well-drained, medium textured soils.

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

Irrigating New Alfalfa

At planting time the soil should contain sufficient moisture to germinate the seed and keep the small plants growing rapidly until they are at least 3 to 4 inches high before the first irrigation. This requires a firm, thoroughly prepared seedbed well supplied with moisture.
For spring seeding this may be accomplished by fall plowing and fall seedbed preparation. Where alfalfa is to follow sugar beets, beans, or potatoes, a good seedbed may be prepared 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. To avoid this danger, many farmers cut the nurse crop for hay while still quite green and irrigate promptly after its removal. Others cut the nurse crop for grain as early as possible on the green side, shock the grain and irrigate at once while the shocks are standing in the field. An additional irrigation during the autumn is recommended.

At the Huntley Field station and in the lower valleys of Montana the practice of seeding alfalfa alone in the spring without a nurse crop on a well-prepared seedbed has resulted in better stands and better yields than planting with a nurse crop. Drilling alfalfa seed alone on grain stubble in early August after the grain is removed, followed by irrigation, has given similar results and is growing in favor.

Where irrigating up is necessary, young stands of alfalfa are best irrigated by the furrow or corrugation method. Fig. 7 shows a home-made sled type corrugator in use. Heavy soils
that puddle when wet and crack when dry, may be handled better by applying the water in furrows than by other methods as this avoids wetting and baking the entire surface. The shallow corrugations are made immediately after planting. After irrigating up, a second light irrigation a week or ten days later is recommended to soften the crusted soil so the tiny seedlings may be able to push through the surface of the ground.

**Pastures**

To produce the greatest returns, irrigated pastures must be kept growing continuously during the entire growing season. Total irrigation requirements are similar to those of alfalfa. The chief difference is that grasses require frequent, light irrigations since their root systems are comparatively shallow. Best results are obtained by applying 2 to 3 inch irrigations every 7 to 14 days throughout the growing season. Fig. 8 shows a pasture in the Yellowstone valley receiving a weekly irrigation.

Sandy soils require lighter, more frequent irrigations than loam soils. The same thing is true of some heavy clay soils that absorb water slowly.

Because most pasture plants are subject to winter injury when the soil is dry, a medium-late fall irrigation is desirable in areas receiving light fall or winter precipitation.

Experiments at the Huntley station and experience of farmers in the Yellowstone valley indicate that in seeding pastures,

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Fig. 8—Pastures require frequent irrigation.
best results are usually obtained from early spring seeding without a nurse crop on a firm, well-prepared seedbed. An even distribution and covering of the seed is obtained if seeded through the grain hopper of a drill, set to run as shallowly as possible. Late summer seeding in grain stubble, is also successful and in some seasons of bad grasshopper infestation often results in better stands than spring seeding. Irrigating the crop up in late summer is less difficult than spring irrigation, particularly on heavy soils which do not bake or dry out as rapidly after an irrigation later in the season.

The most critical time in the management of a grass pasture is from planting until the grass is well started. Even though the seedbed has plenty of moisture at planting time, the surface soil which contains the grass seed will often dry out before germination is complete, unless water is applied. For this reason irrigating up immediately after planting is recommended. The time between irrigations will depend upon the type of soil and the weather conditions. The applications need not be heavy but they should be frequent enough to keep the surface moist.

The corrugation method is advised in irrigating up pastures. The furrows or corrugations may be made with a home-made sled type corrugator, (See Fig. 7) or with a beet cultivator with irrigation shovels attached. For ordinary soils the furrows should be about 24 inches apart. The length of furrows will range from 200 to 600 feet in length, depending upon the type of soil. Heavy soils require longer runs than light soils to allow time for proper penetration.

For the first few irrigations, the water may be confined to the corrugations and not allowed to flood over the surface. This means about one miner's inch per furrow for heavy soils and up to 2 miner's inches for light soils. Heavier irrigations may cause erosion.

After the first season it is not necessary to make fresh corrugations. The old ones will not be entirely filled, and since the grass sod will prevent washing and baking, the pasture can be flooded without harmful results.

At the beginning of the second season and before any heavy grazing is begun, the pasture should be divided into two or more lots by fencing. This makes it possible to graze one lot while the other is being irrigated. A pasture should never be irrigated while the livestock are on it since they cut the wet sod and tramp the grass into the mud.
Small Grains

Total seasonal irrigation water requirements for small grains are about one-third less than that of alfalfa or about 15 acre inches annually. This will vary from 12 inches or less in areas having short, cool seasons and well distributed rainfall, to 18 inches or more in areas of long, hot, growing seasons, subject to drying winds and excessive evaporation.

The total irrigation requirements of barley are less than wheat, and that of oats, more than wheat. The yields of barley and wheat increase rapidly as the total water applied each season approaches 15 to 20 inches while the yield of oats may increase with the application of water up to 25 inches. Yields of all small grains decrease rapidly with the application of excessive amounts of water.

If the seedbed has been properly prepared, the soil should contain sufficient moisture at seeding time, which together with spring rainfall, will assure the crop a good start before irrigation is required.

If only one irrigation is given, it becomes most effective when applied early in the season, from the 5-leaf to the early boot stage. Where two irrigations are given, the 5-leaf and early boot stages are best for wheat and oats, with the 5-leaf and early bloom stages best for barley. For three irrigations the water is applied at the 5-leaf, early boot, and in the early to full bloom stages. Usually better results will follow three irrigations than two, even though no more water is used for the larger number of irrigations. A fourth irrigation seldom increases the yield and often results in lower yields than do three applications.

Irrigation after the early dough stage not only fails to increase yields, but delays ripening and encourages lodging of the grain. Damp weather throughout the growing season or too frequent irrigation tends to promote rust.

The time of application frequently has more influence upon the yield and quality of grain than the number of irrigations or the total amount of water applied. When the grain is in the boot stage, the heads are forming and adequate moisture is required to form heads containing a large number of grains. An even greater demand for moisture occurs while the plants are in bloom to assure fertilization and subsequent filling of every kernel.

The quantity of water to apply at each irrigation depends on the stage of growth of the crop and the capacity of the soil to store water within reach of the plant roots.
Nearly 25 years ago, after several years of study of the production of grains at the Aberdeen substation, Idaho, Aicher made the following statement concerning the time to irrigate that is still particularly true of Montana and for other crops as well:

"Grain should be irrigated when the crop needs water, regardless of the stage of growth of the grains. ... seasons vary and the time to irrigate a crop varies considerably with the season. Summer rains often are misleading, unless they exceed a half inch. Every year they are indirectly responsible for considerable loss in the irrigated section. ... It is a mistake to take the average shower too seriously. The immediate surface moisture is of little value in crop production, and unless the ground is moist to a considerable depth, the crop should be irrigated, regardless of the little moisture from small rains."

Irrigation requirements for small grains are relatively light early in the season and tend to increase as the plant grows in size as indicated in Fig. 4. The general practice is to irrigate heavily in the spring and use less water as the season advances. Water is usually plentiful in the spring, but at the time the grain is in bloom and needs water the most, the supply begins to fail or is needed for other crops. It is better to irrigate moderately in
the spring. The reason is that heavy, early irrigation promotes excess straw growth at the expense of later grain development.

If carefully applied, an irrigation of 4 to 6 inches in depth is ample to fill the upper 3 feet of soil with all the moisture the crop can use at the time and also allow for a reasonable amount of waste. Applications in excess of 6 inches per irrigation usually mean excessive losses due either to surface run-off or deep percolation in the subsoil beyond the reach of plant roots.

When light soils are too dry to permit germination and initial growth, they should be irrigated before seeding.

Some difficulty is experienced as a result of irrigating heavy soils in spring prior to seeding, as the soil dries out slowly and seeding is delayed. When heavy soils are too dry to assure germination and initial growth, it is best to plant the grain in the dry soil and irrigate up. A second irrigation may then be needed before plants are large enough to shade the ground, in order to prevent damage to the emerging crop from the hard crust which usually forms on such soils after irrigation. The corrugation method of irrigation should be used in irrigating just after planting, as this method causes less crusting and packing of the top soil than do flooding methods. Where winter moisture is generally light, moisture for starting spring grain on heavy soils may be supplied by late fall irrigation either before or after fall plowing.

The irrigation applied either before or after planting to bring the crop up should be considered as an extra irrigation in addition to the usual number required during the growing season.

Corn

In general the total seasonal water requirements for corn are only slightly less than those of small grains. The most critical stage of growth in relation to moisture supply occurs at tasseling. Adequate moisture at this time is essential for good yields.

Under irrigation, corn is usually planted flat instead of in lister furrows as is often done with dry land corn. For irrigation, large furrows about six inches deep are made between the rows with regular irrigation shovels attached to the cultivator. Water is applied in these furrows. Surface flooding should be avoided.

General observations indicate that a single irrigation for corn is most effective when given in July, or at tasseling time.

In ordinary seasons two irrigations may be all that are required. Three irrigations may be needed during drier years. Regardless of the number of irrigations, the last one should usually be given not later than August 15, since irrigation later than this will delay maturity.
The yields of corn under irrigation increase rapidly with increased amounts of irrigation water up to 20 inches a year. The yield decreases as more than 25 inches of water is applied. Applications from 4 to 6 inches in depth from each irrigation is good practice in corn growing.

**Sugar Beets**

Sugar beets grow best when supplied with ample moisture during the entire growing season. The yield of beets increases rapidly as the water applied is increased up to 15 inches per season. Above 15 inches yields may slowly increase. More than 30 inches per year generally results in decreased yields. Excessive as well as deficient irrigation seriously injures the crop.

The old idea that irrigating beets early in the season prevents deep rooting, and that late irrigation reduces the sugar content of the beets is not based on facts. The beets should be irrigated whenever the leaves turn a dark green color or begin to wilt in mid-day and do not quickly recover at night. This is true whether the beets have only a few leaves or are nearing maturity.

In some localities it is necessary to irrigate before or immediately after planting to insure prompt germination. Lighter soils may be irrigated before rather than after planting. As soon as the land can be worked it is smoothed down and planted.

With heavy soils it is advisable to plant the beets at the usual time and then irrigate them up. This is because early spring irrigation not only delays time of planting but also makes it difficult to prepare a suitable seed bed. Where irrigation follows planting, ditches should be attached to the drill to furrow the rows.

Many expert growers make a regular practice of irrigating lightly as soon as the crop is planted or at least once before thinning in order to insure rapid early growth.

The amount of water to apply at each irrigation depends upon root development and the type of soil. Early irrigations should not be as heavy as those later in the season. This is sometimes accomplished by irrigating the first time in every other row. See Fig. 10.

A shallow sandy soil is able to absorb and hold only 2 or 3 inches of water within reach of plant roots, while a clay loam can absorb and hold 5 or 6 inches or more of water at one irrigation. On sandy soils it may be necessary to irrigate lightly every week during the summer while soils having a greater water holding capacity may be irrigated more heavily at intervals of two or three weeks.
Care should be taken to distribute the water evenly in all furrows and to give all parts of the field an equal irrigation. If the distance between laterals is very long, distribution will be uneven and water wasted. Washing and flooding are caused by running too much water in a furrow. Flooding or ponding should be avoided in all cases as it wastes water, forms crusts and sometimes kills the plants. See Fig. 11.

Beets should be irrigated late enough so they will continue growth up to the digging time, with the soil kept moist but not muddy.
Potatoes

Before potatoes are planted it is important that the soil be well supplied with moisture in order to germinate the potato seed pieces and give them a good start before the first irrigation. Maximum yields of marketable potatoes will be obtained by keeping the ground moist enough throughout the season to encourage continuous growth. This requires that the first irrigation be applied as soon as the moisture content of the top 8 or 10 inches of soil drops below that required for ideal plant growth.

The color of the potato foliage is a good index to the amount of moisture in the soil available to the plant. Plants supplied with the proper amount of moisture for good growing conditions have a normal color of foliage for the variety. The foliage assumes a darker green color as the supply of moisture is diminished in the soil. Plants suffering for want of water have a decidedly dark, blue-green color. Excess water in the soil is indicated by a light-green appearance of the foliage.

For maximum yields the first irrigation should be applied before the plants turn dark green, i.e., before the plant shows any marked evidence of water shortage, regardless of the size or stage of growth. This may be any time from the time plants are a few inches high, up to the time of full bloom. This depends on variations in water-holding capacity of the soil and seasonal conditions, including temperature and rainfall.

After the first irrigation, the soil should be kept moist during the remainder of the growing season by light, frequent irrigations until about the first of September or about one month before digging time. The soil should never be permitted to get dry between irrigations. Some seasons may require two or three irrigations, others six or eight, or more.

During irrigation, water should be allowed to run in the furrows until the soil in the row under the hills becomes moist. The soil is properly irrigated when it forms a ball and moistens the hand when compressed. Heavy applications of irrigation water sufficient to saturate the soil below the tubers should be avoided.

Under average conditions the yield of potatoes increases with increase of irrigation water up to 20 inches in depth per season. The application of water in excess of 20 inches annually has resulted in decreased yields. Single irrigations from 2 to 3 inches in depth should be sufficient to provide moisture for con-
Continuous growth. Heavier applications often result in soggy tubers and also may reduce the yield.

Under no circumstances should potatoes be flooded. They should be irrigated by means of furrows placed between the rows. Such furrows should be 6 to 8 inches deep so that a small stream may be run through them without danger of overtopping and flooding the surface of the ground around the plants. The water in the furrow should not exceed one or two inches in depth. The length of run may be adjusted to provide uniform penetration of moisture throughout the length of the row. Light cultivators should be given as soon as possible after each irrigation and the rows furrowed out again for each following irrigation until the vines become too large for cultivators. Fig. 12 shows potatoes properly furrowed for irrigation.

If the ground is too dry in the spring to insure germination, irrigating before planting is preferable to "irrigating up." Where plowing has been delayed, the land may be irrigated before plowing and seedbed preparation.

Irrigating up is fairly successful if substantial furrows between the rows are provided, and water is applied immediately after planting. Even though the top soil of the ridges becomes wet, good results may be obtained providing the field is not flooded. Cultivation and harrowing the soil should follow as soon as the condition of the soil permits.

Delay in "irrigating up" results in poor germination.

Fig. 12—Deep furrows are used in irrigating potatoes to prevent flooding.
Seed Peas

Seed peas do best on medium textured loam soils having a rather high water absorbing and holding capacity. There are no set rules for the irrigation of seed peas, but the time of irrigation is important. The total annual irrigation requirements for peas are somewhat less than for barley.

Early bloom is the most critical stage of growth in relation to moisture supply and yield. Whenever possible the first irrigation should be applied just as the peas are coming into bloom. One moderately heavy irrigation of 5 or 6 inches applied at this time often results in better yields than where more irrigations are applied, provided there has been sufficient moisture in the soil to bring them that far without the ground becoming too dry. If more than one irrigation is applied, 3 to 4 inch applications are recommended. Heavy, early irrigations tend to produce vine growth at the expense of seed yield.

Regardless of when the first irrigation is given the growing crop, additional irrigations, if applied, should be given at frequent intervals before the ground dries out. If the ground becomes dry, later irrigations seem to stop the growth of the plants.

Peas show the need of water by turning a bluish or bluish-gray color. When spots in the field begin to show this color, irrigate, whether they are two inches high or in bloom. In case the soil bakes badly from early irrigation before the peas shade the ground, a second light irrigation within a week or 10 days may help to overcome this condition.

If the ground is too dry to start the peas in the spring, irrigate before planting or corrugate and irrigate immediately after planting rather than plant and delay a week or so before irrigating.

When the water is kept moving and the runs are not too long, scalding rarely occurs unless the ground has first become too dry for normal crop growth. Peas should be irrigated before they show any pronounced need for water as they cannot recover after having once stopped growing because of water shortage.

Field Beans

The Great Northern is the principal variety of field bean grown in Montana. Irrigation studies indicate that it is as easy to over-irrigate as to under-irrigate field beans. Beans are not heavy users of water. One irrigation during the blossoming period in order to insure a heavy “set” of pods is all that is necessary some years. Usually two irrigations give higher yields than three
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or more irrigations. Sandy or gravelly loam soils require more frequent irrigations than loams and clay loams.

Beans should be irrigated before the plants begin to show a dark green color and commence to wilt during the hot part of the day, regardless of the stage of growth of the plant.

If the soil is dry in the spring, it is good practice to irrigate the land before planting, followed by seedbed preparation and planting. Irrigated in this way, two irrigations are more effective than three applied after the beans are planted.

No attempt should be made to moisten the soil deeper than the depth penetrated by the bean roots. If the soil is moistened to a depth of 1 or 2 feet, it should be sufficient to enable the beans to make good growth.

The last irrigation should very seldom be given after the blooming period. Just as the plants are coming into bloom is as late as water should be applied in ordinary seasons, and on ordinary soils. Later irrigations delay the maturity of the crop and endanger proper ripening, because of possible frost injury. Such later irrigations do not materially increase the yield of beans.

The chief consideration, either on irrigated land or dry land, is good, thorough cultivation. Such cultivation should be given as soon after irrigation as possible to get on to the land. The aim should be to prevent the loss of water by cultivation rather than to furnish water by excessive irrigation.

For more detailed information regarding the irrigation of general field crops, readers are referred to the following publications:

3. Fortier, Samuel—Irrigation practices in growing alfalfa—USDA FB 1630 (1940)
6. Nuckols, S. B.—Sugar beet growing under irrigation in the Utah-Idaho area. USDA FB 1645 (1931)


10. McLaughlin, W. W.—Irrigation of small grain—USDA FB 1556 (1937)

