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Russian knapweed recently introduced into Utah. Left: Stem, leaves, and flowers. Right: Underground stem (rootstock)
INTRODUCTION

There are in Utah a number of weeds considered to be unusually persistent and difficult to eradicate once they have become established. The most common in this group are wild morning glory, whitetop, Canada thistle, perennial sow thistle, and Russian knapweed, the last being one of comparatively recent introduction. The weeds in this group are quite generally feared and much talked of by farmers. They are feared because, if allowed to persist, they usually take possession of the soil and hinder the growth of farm crops. The discouraging fact about these weeds is their spread. Old infested areas are increasing in size, and each year new lands are becoming infested. In time practically every farmer in Utah will be fighting one or more of these weeds unless some vigorous measures are taken to keep them in check.

On the other hand, there is another group of weeds much less
feared by the farmers but which is causing far greater total losses to Utah's crops because of their wide distribution. These are mostly annuals in nature, such as red root, purslane, Russian thistle, and lamb's-quarters. One or more weeds of this group is present on every farm in Utah and is materially affecting acre-yields and the quality of the crop harvested.

A survey made in the summer of 1926 of Utah, Salt Lake, Weber, Davis, Boxelder, Tooele, and Cache Counties showed that about 85 per cent of the fields have weeds interspersed with the crops. The area of the land occupied by these weeds covers from 5 to 90 per cent of the fields.

**LOSSES DUE TO WEEDS**

It is difficult to arrive at the exact loss that occurs each year in Utah due to weeds, but undoubtedly it amounts to millions of dollars; moreover, there is an occasional death of some individual caused by eating the roots of a poison weed. In addition, there is the great annoyance and suffering from hay fever which is caused largely by weeds.

It is estimated that the average annual loss to the various crops in the United States is as follows:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Loss Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastures</td>
<td>20-25 per cent</td>
</tr>
<tr>
<td>Spring grain</td>
<td>12-15 per cent</td>
</tr>
<tr>
<td>Corn</td>
<td>10 per cent</td>
</tr>
<tr>
<td>Hay</td>
<td>10 per cent</td>
</tr>
<tr>
<td>Potatoes</td>
<td>8 per cent</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>7 per cent</td>
</tr>
</tbody>
</table>

This does not include the additional loss that results from the hibernation of insects and the harboring of diseases which attack crops.

Some of the ways by which weeds cause losses will be briefly considered.

**Weeds Rob Crops of Moisture.**—In Utah the water-supply is the chief limiting factor in crop production. Only a small part of the land in the state can ever be put under irrigation. Therefore, the economical use of irrigation water and the careful conservation of the moisture that enters the soil through rains are of primary importance. Weeds are known to rob the soil of invaluable moisture that should go to the crops. Scientific workers have determined how much water is necessary to produce a given weight of dry plant material; this is spoken of as the "water requirement". It has been determined for a large number of crop plants as well as for some
Fig. 2.—A summer fallow free from weeds is an important requisite to successful dry-farming. It helps to conserve soil moisture. Sowing clean seed under such conditions insures a clean crop free from weeds.

common weeds. The water requirements of a number of crops and weeds, as quoted by Robbins and Boyack (24), are given in Table 1.

Table 1. A comparison between a few crop plants and weeds as to the pounds of water required to produce one pound of dry plant material (24)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Pounds of Water Used by Plant to Produce One Pound of Dry Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>368</td>
</tr>
<tr>
<td>Wheat</td>
<td>513</td>
</tr>
<tr>
<td>Barley</td>
<td>534</td>
</tr>
<tr>
<td>Oats</td>
<td>597</td>
</tr>
<tr>
<td>Sweet clover</td>
<td>770</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>831</td>
</tr>
<tr>
<td>Pigweed</td>
<td>287</td>
</tr>
<tr>
<td>Russian thistle</td>
<td>336</td>
</tr>
<tr>
<td>Gumweed</td>
<td>608</td>
</tr>
<tr>
<td>Sunflower</td>
<td>683</td>
</tr>
<tr>
<td>Lamb’s-quarters</td>
<td>801</td>
</tr>
<tr>
<td>Ragweed</td>
<td>948</td>
</tr>
</tbody>
</table>

It is evident from Table 1 that the common weeds which occur in the fields and gardens draw heavily on the soil moisture. Common sunflower requires about twice as much water to produce a pound of
dry material as does corn. To the dry-farmer this is of vital importance, since on the conservation of the moisture depends the success of the crop. A summer fallow practiced to conserve moisture is worthless if allowed to grow up to weeds because weeds exhaust the soil of the moisture as thoroughly as does a crop of wheat. To be effective a fallow should be kept free from weeds. Experiments conducted in Utah (29), as given in Table 2, show that from the standpoint of moisture conservation and crop production it is as effective to keep weeds hoed down as to keep the soil well cultivated.

Table 2. Yield of wheat of fall- and spring-plowed plats receiving ordinary cultivation as compared with plats kept free from weeds simply by hoeing or pulling.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Acre-yield (Bu.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1916-1927</td>
</tr>
<tr>
<td><strong>Spring Plowed</strong></td>
<td></td>
</tr>
<tr>
<td>Ordinary tillage</td>
<td>25.2</td>
</tr>
<tr>
<td>No tillage; weeds hoed</td>
<td>25.2</td>
</tr>
<tr>
<td><strong>Fall Plowed</strong></td>
<td></td>
</tr>
<tr>
<td>Ordinary tillage</td>
<td>26.8</td>
</tr>
<tr>
<td>No tillage; weeds hoed</td>
<td>24.9</td>
</tr>
</tbody>
</table>

Weeds Rob Crops of Plant-food.—By chemical analysis all plants are found to contain materials known as plant-foods. The air is the source of some of these, while others come from the soil. Nitrogen, phosphorus, and potassium are the plant-foods most likely to be lacking in the soil. Since all plants must have a certain amount

Table 3. A comparison of the amount of nitrogen, phosphoric acid, and potash removed from the soil by a few common crops* and weeds**.

<table>
<thead>
<tr>
<th>Crops</th>
<th>1000 Pounds of Dry Material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrogen</td>
</tr>
<tr>
<td><strong>Crops</strong></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>23.8</td>
</tr>
<tr>
<td>Corn fodder</td>
<td>12.5</td>
</tr>
<tr>
<td>Sugar-beet (root)</td>
<td>2.6</td>
</tr>
<tr>
<td>Potato (tuber)</td>
<td>3.5</td>
</tr>
<tr>
<td>Oat hay</td>
<td>13.4</td>
</tr>
<tr>
<td><strong>Weeds</strong></td>
<td></td>
</tr>
<tr>
<td>Purslane</td>
<td>35.7</td>
</tr>
<tr>
<td>Chickweed</td>
<td>38.5</td>
</tr>
<tr>
<td>Lamb's-quarters***</td>
<td>39.9</td>
</tr>
<tr>
<td>Wild morning glory**</td>
<td>36.2</td>
</tr>
<tr>
<td>Field daisy</td>
<td>22.6</td>
</tr>
<tr>
<td>Saltbushes</td>
<td>21.6</td>
</tr>
<tr>
<td>Chess or cheat</td>
<td>11.5</td>
</tr>
</tbody>
</table>

*In the case of alfalfa, the larger portion of the nitrogen comes from the air.

**Feeds and Feeding. Henry, W. A. and Morrison, F. B. (1923)

***Green Manuring. Pieters, A. J. (1927)
of these materials it means that weeds, when growing in crops, are competing with the crops for the essential plant-food. Table 3 gives the amount of these important plant-foods removed from the soil in 1000 pounds of dry plant material.

From a study of Table 3 it is obvious that some weeds are relatively high in important plant-foods. Purslane, chickweed, lamb's-quarters, and wild morning glory all contain considerably more nitrogen, phosphorus, and potassium in 1000 pounds of dry material than the crops given. This indicates that these weeds are apparently heavy feeders on the important plant-foods. Since the soil is the only source of these materials, it is likely that weeds play an even more important part in robbing crops of plant-food than is commonly supposed.

**Weeds Cause Lower Crop Yields.** As a result of this competition for food and water, associated with the crowding and the shading of the crop, acre-yields are very noticeably reduced.

In Kansas (6) the yield of wheat on land infested with morning glory is reported to be less than half the yield on clean land, and under droughty conditions the crop is usually a failure when morning glory is present.

A comparison was made at the Fort Hays Experimental Farm (Kansas) (6) as to the effect of morning glory on yield of close-drilled sorghum and sudan grass. The yields are given in Table 4.

**Table 4. The effect of morning-glory on acre-yields of sorghum and of sudan grass as a 4-year average (Fort Hays, Kansas, 1919-22)**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Date of Seeding</th>
<th>4-Year Average, 1919-1922</th>
<th>Percentage Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum</td>
<td>Early June</td>
<td>2.06 tons</td>
<td>3.92 tons</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Early June</td>
<td>1.92 tons</td>
<td>3.54 tons</td>
</tr>
<tr>
<td>Sudan grass</td>
<td>Normal</td>
<td>1.54 tons</td>
<td>2.2 tons</td>
</tr>
</tbody>
</table>

In the summer of 1927 at the Central Experimental Farm at North Logan (Greenville) it happened that at the end of a series of irrigated plats of different varieties of wheat, the land was infested with wild morning glory (*Convolvulus arvensis*). A small plat (10.89 square feet) was cut from each plat infested with morning glory, as was a similar plat from outside the infested area. Eleven plats were obtained under each of the two conditions. The average acre-yield for the wild-morning-glory-infested area was 57.7 bushels per

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1Leguminous crops when properly inoculated obtain most of their nitrogen from the air.
acre as compared to 72.4 bushels per acre for the non-infested area, or 20.3 per cent decrease due to wild morning glory. In this case the yield on the morning-glory-infested area is rather high. This was possibly due to the fact that during the previous year potatoes occupied the land: the morning glory was cultivated and hoed a number of times during the season and then plowed under in the fall. This weakened the weed to such an extent that it failed to make a very vigorous growth until late summer, whereas the wheat was planted early and made much of its growth before the morning glory recovered.

Weeds Increase the Cost of Producing Crops. Weeds are often the cause of crop failures. It is frequently necessary to delay seeding in the spring in order to kill the weeds before the crops are planted. This necessitates extra cultivations which adds to the cost of producing the crop. If the spring happens to be dry, poor stands, or even complete crop failures, often result. On the other hand, if the crop is seeded before the weeds are killed, the weeds grow up with the crop. They crowd and suppress the crop and thereby cause thin stands: by this time, it may be too late to reseed. As a consequence, the yields are low and the crop returns are often less than the cost of production.

During the summer, extra cultivations are necessary to keep weeds in check. Possibly several cultivations could be dispensed with if it were not for weeds. They greatly increase the land labor required to produce crops in the trucking districts. Onion growers in Davis County are constantly struggling with purslane to keep it from overrunning their fields. In the production of onions, for example, it is estimated by Mr. A. L. Wilson, Superintendent of the Davis County Experimental Farm, that it costs from $50 and $60 an acre to eliminate weeds alone.

The harvesting costs are also increased where weeds are present. Large sunflowers, prickly lettuce, sweet clover, or other large weeds, when present in grain fields, materially hinder the progress of harvesting. Such weeds cause extra wear on machinery and often cause breakdowns.

Weeds Increase the Cost of Marketing. It is estimated that in 1923 the spring-wheat farmers of North Dakota, South Dakota, Minnesota, and Montana produced nearly 12,000,000 bushels of screenings in the wheat crop. This material is known commercially as dockage. It consists largely of weed seeds. It cost the farmers, of the four states, more than $675,000 to thresh this dockage. It took over 13,890 cars to haul it to market with a freight
charge amounting to $800,000. This loss does not take into account
the loss in acre-yield due to the presence of weeds growing with the
crop.

During this same period, according to data obtained on the grain
graded at Logan, Utah, the farmers of Utah produced 161,805
bushels of dockage in the wheat crop. This heavy expense for handling, shipping, and marketing is all borne by the farmer. The decrease in value of the wheat crop in Utah, due to the presence of weed seeds and other foreign material, is estimated to be at least a quarter of a million dollars.

Weeds Reduce the Value of Farm Products. Frequently weeds are green when the grain crop is cut. This delays the curing of the grain and in some cases causes molding, or even heating in the shock or stack. Immature weed seeds and small pieces of weeds often find their way into the threshed grain and cause the grain in the bin to heat. Even when heating does not occur, weeds occasionally impart an objectionable odor to the grain which makes it practically worthless for flour manufacture.

Garlic bulblets present in wheat often reduce its commercial value 50 per cent and sometimes make it difficult to dispose of the wheat at any price.

Corn cockle, when present in wheat and ground into the flour, has a deleterious effect on the bread made therefrom. Flour (4) made from wheat containing 10 per cent corn cockle reduced the color of the bread from a score of 95 to 70; the texture was reduced from 94 to 50; and the volume of the loaf from 2550 cubic centimeters to 900. In addition, the seed of corn cockle is poisonous (9), and such flour would be dangerous as food.

The Official United States Grain Standards recognize weed seeds not separable by machinery as an important grading factor. Only a small quantity need be present, after dockage is determined, to lower the grade. Alfalfa-seed grades, as adopted by Utah, Idaho, and Montana, permit only traces of weed seeds, and no noxious ones at all, in the higher grades.

Alfalfa-seed growers have experienced considerable difficulty in marketing alfalfa seed containing dodder seeds, especially the large-seeded species. One of the important measures of quality in the "Alfalfa and Alfalfa-mixed Hay" standards is the percentage of foreign material present. An excess of 5 per cent of weeds will lower the grade to No. 2. More than a trace of such weeds as mature barley grass, sandburs, and poison plants are considered injurious foreign
material and lower the hay immediately to sample grade.

Freedom from weeds and weed seeds is one of the important requirements in grain and alfalfa seed certification requirements.

Certain weeds, when eaten by the dairy cow, impart a disagreeable odor to milk.

Another loss from weeds, which farmers should not overlook, is that which occurs to the sheep industry. The presence of cockleburs and similar burs in the wool is becoming a very serious problem. Certain sections have already established a reputation for producing wool that is filled with cockleburs. These sections are now having difficulty in getting wool buyers interested in their product.

Weeds Harbor Insects and Diseases. Many of the insects destructive to farm crops either hibernate or breed on weeds. The "white fly", or sugar-beet leafhopper, which is the agency in transmitting the curly-top disease, probably depends to a great extent on weeds for breeding and hibernation. Some agriculturists think that weeds along fence lines, ditchbanks and waste places are partially responsible for the troubles caused by the sugar-beet leafhopper each year. The beet webworm frequently deposits its eggs on such weeds as lamb's-quarters and Russian thistle. On hatching, the larvae migrate to the beet fields and feed on the beet leaves. The Colorado potato beetle, which causes large losses to the potato crop in some sections, thrives on weeds such as buffalo bur, the various night shades, and other weeds in the potato family; later it migrates to the potato fields. The virus of the diseases of degeneration of potatoes, which has threatened the potato industry, occurs in weeds which thereby serve as a source of constant contamination to potato fields.

It is stated (26) that certain forms of the fungus causing stem rust of wheat are harbored by certain grasses such as wild barley. The disease may spread from wild plants to wheat fields, causing great losses to the crop.

Poison Weeds Cause Heavy Loss to Livestock. It is estimated (15) that the average loss of animals on the range is between 3 and 5 per cent, and, of this, 90 per cent is due to poison plants. In 1920 records (23) show that there were on the National Forests of the United States approximately 2,250,000 cattle and horses (animal units) and over 7,000,000 ewes with about three-fourths as many lambs. The additional losses of livestock on the public domain and on farms due to poison plants also represent considerable drain on the livestock industry.

Mortgage of Weeds. A mortgage on a farm is to the farmer a
serious financial drain because it is so constant. As long as he pays merely interest the cost is perpetual. The size of the mortgage can be reckoned from the size of the interest payment. Extra labor to control weeds has the same effect. The average acre-cost in Utah for controlling weeds in common crops is about as follows:

- Corn _________________________ $4 to $6 an acre
- Sugar-beets _______________________ $7 to $9 an acre
- Potatoes ______________________________ $8 to $10 an acre
- Truck crops ______________________ $12 to $20 an acre

These costs measure only the effort to fight back the weeds. Yield losses and losses in market value are to be added. Counting interest on the mortgage at 7 per cent, these constitute mortgages of from about $50 an acre on corn land to $200 or $300 an acre on truck-crop land. Who would consider accepting such a loan mortgage without getting anything in return? And yet this is just what the farmer is doing who neglects weed control. Moreover, the payments are continuous until he cleans up his farm and keeps it clean. Clean farming can reduce the annual payments to a small fraction of the average present cost.

The market value of farm land is decreased by the amount of the mortgage covering the land. A loan mortgage is a financial obligation; weeds are a natural obligation, but the effect is the same. Perennial weeds, such as morning glory or whitetop, often ruin the sale of a farm. When they do not do this, they greatly reduce its value for sale or as collateral for loans. Federal land banks are in many cases refusing loans on farms heavily infested with morning glory.

WHY WEEDS FLOURISH

In nature there is a constant struggle for existence. It occurs both in the plant and in the animal kingdoms. Beginning with the lichens on solid rock, and lasting through the many ages that are required to produce good soil from these rocks, plants constantly compete with each other. One group of plants survives for a time, but when conditions gradually change another group takes possession, each able to crowd out the other under these changed conditions. Thus, plants have passed through many stages, with the gradual elimination of those that have not been able to survive. Because of some special adaptations, weeds have survived. Crop plants, on the other hand, have been artificially selected for many generations without regard to their ability to survive in competition with other plants. In
fact, crop plants have been so carefully nurtured by man for so many
generations that they have largely lost their ability to survive under
natural conditions. Weeds, therefore, are better able to care for them-
selves than are crop plants. Most of the latter would be lost if turned
back to nature to compete in the wild state. Finally, with the ever-
increasing keenness of competition and because of certain peculiar
devices they possess, weeds have become more and more able to main-
tain themselves. Some of the more important characteristics weeds
possess in maintaining themselves are briefly discussed in the following
pages.

*Ability to Produce Large Numbers of Seeds.* Certain weeds are
able to survive merely because they produce an extremely large num-
ber of seeds, as shown in Table 5.

Table 5. Estimated number of seeds borne by a moderate-sized plant of a few
common weeds.

<table>
<thead>
<tr>
<th>Common Name of Weed</th>
<th>Estimated No. of Seeds Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purslane</td>
<td>1,250,000</td>
</tr>
<tr>
<td>Tumbling mustard</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Mullein</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Russian thistle</td>
<td>150,000</td>
</tr>
<tr>
<td>Shepherd's purse</td>
<td>50,000</td>
</tr>
</tbody>
</table>

It is evident from Table 5 that one need not let many plants of
such weeds as plantain or tumbling mustard go to seed to produce
sufficient seed to sow a large area. The tumbling habit of tumbling
mustard and Russian thistle makes them both the more capable of
surviving. Others commonly inhabit ditchbanks where their in-
umerable seeds fall into the water and are thereby carried to the fields.

*Seeds of Some Weeds are Small and Hence Escape Notice.* Many
weeds produce seeds so small as to escape notice. Seeds of dodder,
purslane, chickweed, and many others are of this nature. Table 6,
which indicates the number required to make a pound, gives an idea
of the smallness of some weed seeds. The number of alfalfa seeds in
a pound is given for comparison.

With such small seeds as indicated in Table 6, it is not uncom-
mon to find hundreds of them in a pound of crop seed. To illus-
trate, suppose wheat was sown at the normal rate of two bushels an
acre and contained 1 per cent of wild mustard seed. There would be
sown 388,791 mustard seeds to the acre, or enough for nine seeds on
every square foot. Too often this kind of seed is sown, with the
result that the field grows up to weeds and only about half a crop of
grain is harvested.

Table 6. Approximate number of seeds of various weeds in a pound, as compared to alfalfa seed.

<table>
<thead>
<tr>
<th>Name of Weed Seeds</th>
<th>No. of Seeds per Pound (Approximate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>250,000</td>
</tr>
<tr>
<td>Purslane</td>
<td>2,000,000</td>
</tr>
<tr>
<td>Lamb’s-quarters</td>
<td>604,786</td>
</tr>
<tr>
<td>Russian thistle</td>
<td>266,817</td>
</tr>
<tr>
<td>Wild mustard</td>
<td>215,995</td>
</tr>
<tr>
<td>Wild oats</td>
<td>25,493</td>
</tr>
<tr>
<td>Wild morning glory</td>
<td>215,995</td>
</tr>
</tbody>
</table>

An illustration of the importance of the size of weed seeds and the dangerous relation they bear to farming was found in a sample of alfalfa seed sent for analysis to the Agronomy Department of the Utah Agricultural Experiment Station. It had a purity of 95 per cent; the impurity consisted of small dodder seeds, Russian thistle, and green foxtail in sufficient numbers that a sowing of this seed at the rate of 15 pounds an acre would have been sufficient weed seed to sow 61 dodder, six Russian thistle, and five green foxtail seeds on every square foot of land. This only emphasizes the fact that a sample of seed may appear at a casual glance to be practically free from weed seeds and yet, due to the small size, contain a large number.

Some Weed Seeds Remain Viable for a Long Time. The seeds of some weeds retain their ability to grow after being in the soil for long periods of time. Especially is this true of those that have been plowed under rather deeply. The seeds within a few inches of the surface will probably germinate or die within a year or two. Seeds of erect pigweed, black mustard, shepherd’s purse, dock, yellow foxtail, chickweed, wild mustard, and French weed are all considered to retain their viability for several years under the right conditions.

Weed Seeds often Resemble Crop Seeds. Many weed seeds resemble the crop seeds in which they are commonly found, both in size and in general appearance, thereby escaping attention of any but the careful observers. This is especially true of dodder seed which is commonly found in alfalfa seed. The farmer failing to recognize the dodder seed purchases the seed and sows it.

Often seeds, such as sweet clover and yellow trefoil, when present in alfalfa require a trained analyst to distinguish them from the
alfalfa seeds. This is true of many other weed seeds and further emphasizes the importance of having seeds analyzed before they are purchased. Then too, weed seeds so near the size of the crop seeds in which they are found are difficult to remove. Sometimes it is impossible to do so except by hand-picking.

Some Weed Seeds Exhibit Dormancy. The seeds of such weeds as pigweed, cocklebur, and wild oats remain in the soil for a year or more and fail to germinate, even under ideal conditions, because they remain dormant for a certain period of time. Not until this period has elapsed will they germinate. The old saying that, “One year’s seeding means seven years’ weeding,” is based partly on this fact. Needless to say, such weeds demand especial care to prevent their producing seeds.

Some Weeds Possess a Disagreeable Taste or Develop Thorns or Spurs on the Foliage. Weeds which possess a disagreeable taste or odor or which bear thorns or Spurs are not eaten by animals and, therefore, flourish, whereas the more palatable and useful plants are grazed freely. This is what happens in pastures where weeds such as milkweeds, ragweeds, gumweeds, cockleburs, and thistles are avoided by animals. They are allowed to bear abundant seed unless mowed or otherwise prevented.

Some Weeds are Especially Adapted for Wind Distribution. Many of the so-called tumbleweeds are especially adapted for the scattering of their seeds by the wind. Such weeds as Russian thistle, tumbling saltbush, tumbling mustard, and tumbling pigweed, when mature, break off at the surface of the ground and roll before the wind. As they tumble along the seeds are shaken out. These rolling weeds are frequently the vehicle for other weeds, such as witch grass and barley grass, which catch in the tumble weeds and thereby ride along scattering their seeds.

Some Weeds Have Strong Power to Produce Vegetatively. Among the weeds that reproduce vegetatively some of them are most difficult to control. Morning glory, whitetop, Canada thistle, perennial sow thistle, and Russian knapweed, for example, have adopted this most effective method of surviving in the struggle with other plants. These plants develop stems under the ground which are called “underground stems”, rootstocks, or stolons. Along these underground stems new shoots arise at intervals, and it is by this means the plant spreads. The rootstocks may also be broken into several parts, each of which is capable of developing a new plant.
The Roots of Some Weeds Will Grow After a Period of Air-drying. The familiar saying, "Hang it on the fence for a month, and if given half a chance it will grow", indicates that it is a belief among some people that weeds will grow after being subjected to drying for a period of time. An interesting experiment was conducted in Iowa (20) to determine just how long the roots of various weeds could withstand drying and then grow if placed under proper conditions. Roots or rootstocks of 29 perennial weeds were dug and each separated into six bundles of five each on a total of 30 roots from each weed. The roots were not washed, but the soil was shaken off and the tops removed. The part of root used varied with the type of root system. With those plants with a fleshy tap root such as curled dock, burdock, sunflower, and dandelion, the entire crown was included. While in those weeds that produced rootstocks, such as quack grass and morning glory, a 6-inch piece of rootstock was used. The six separate lots of roots or rootstocks were dried by placing them in containers in a well-ventilated shed. At the end of five days and at 5-day intervals up to 30 days one bundle of roots representing each weed was taken to the greenhouse, covered lightly with moistened sand, and held under good growing conditions for 40 days. Curled dock leads the list by growing after air-drying for a period of 20 days. It was the only weed that grew after more than ten days of air-drying.

Table 7. Roots of various weeds which grew after air-drying.

<table>
<thead>
<tr>
<th>Failed to grow after 5 days of air-drying</th>
<th>Grew After</th>
<th>20 days but not after 30 days of air-drying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nettle</td>
<td>Meadow sunflower</td>
<td>Smooth dock</td>
</tr>
<tr>
<td>Horse nettle</td>
<td>Field milkweed</td>
<td>Dandelion</td>
</tr>
<tr>
<td>Hedge nettle</td>
<td>Cypress spurge</td>
<td>Quack grass</td>
</tr>
<tr>
<td>Canada thistle</td>
<td>Indian hemp</td>
<td>Bouncing Bet</td>
</tr>
<tr>
<td>Ox-eye daisy</td>
<td>Burdock</td>
<td></td>
</tr>
<tr>
<td>Buckhorn</td>
<td>Goldenrod</td>
<td></td>
</tr>
<tr>
<td>Catnip</td>
<td>Swamp milkweed</td>
<td></td>
</tr>
<tr>
<td>Dropseed grass</td>
<td>Flowering spurge</td>
<td></td>
</tr>
<tr>
<td>Hoary vervain</td>
<td>Horseradish</td>
<td></td>
</tr>
<tr>
<td>Artichoke</td>
<td>Cermander</td>
<td></td>
</tr>
<tr>
<td>Devil's shoestring</td>
<td>European morning</td>
<td></td>
</tr>
<tr>
<td>American morning glory</td>
<td>glory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sheep sorrel</td>
<td></td>
</tr>
</tbody>
</table>

The data presented in Table 7 indicate that the roots of some weeds will grow after a certain amount of air-drying. Under field conditions, where weeds are cut or pulled and left on top of the soil
Weeds with the tops attached, this would tend to shorten the drying period necessary to kill the roots. Some weeds will recover after being pulled if the roots are allowed to come in contact with the moist soil. Purslane under such conditions has been known to recover sufficiently to mature its seed.

Weeds with Seed Possessing Thorns or Burs. Some weeds, such as hound's tongue, cocklebur, burdock, and sandbur, produce seed with claws or spines which lodge in the wool or hair of animals to be carried about and thereby scattered. Weeds have adopted many other devices in their struggle for existence. The purslane with its thick waxy leaves may resist wilting and finally recover even when pulled from the ground and left lying in contact with the damp soil.

With so many devices for competition and survival to test the wits of man, one should not be surprised to find weeds in all nooks and corners of every community. They creep out from the edges of stones or out of a crack; along the pathway, they cover all the ground not constantly trodden; in waste places they mar the landscape; and in crops they crowd and struggle for supremacy. No farmer is exempt from weeds. To control them he must learn their ways. He must learn to know weeds, how they get to the farm and what they can and cannot withstand, and how best to strike into their weakest parts.

HOW WEEDS ARE BROUGHT TO THE FARM

To know how weeds are brought to the farm is of great importance to the farmer. The old saying, "An ounce of prevention is worth a pound of cure," is not overemphasized when applied to the control of weeds. Therefore, brief consideration will be given to a few of the ways by which weeds get to the farm.

In Crop Seeds. Man himself is probably the greatest agent in bringing weeds to the farm. Most of the weeds, and especially many of the most troublesome, have been introduced from foreign countries in impure crop seeds. Once having been introduced to this country, it is only a matter of time until they are found in every spot where they will grow. Russian thistle was introduced into the Dakotas from Russia in impure flaxseed by a colony of Russians, and in a few years it had scattered over the entire western area. The seeds of Russian thistle are very common in alfalfa seeds. Tumbling mustard (a native of central Europe) was brought to this country in impure seed; in 25 years it had made its way over most of the United States. The Russian knapweed was introduced into this country in Turkestan
alfalfa seed. It is now found in several alfalfa-seed-producing sections of the state and promises to become a serious pest. Canada thistle, another famous weed, was introduced from Europe in impure seeds. Many other troublesome weeds might be cited as examples of what man has brought to the farm in crop seeds.

To get an idea as to the purity of grain being seeded on Utah farms a survey was made in the spring of 1926. The county agricultural agents in Juab, Davis, Wasatch, Beaver, Morgan, Sanpete, and Sevier Counties collected grain from grain drills during the planting season and forwarded these samples to the Agronomy Department of the Utah Agricultural Experiment Station where they were analyzed. Out of a total of 80 samples collected 57 were of wheat, 13 of barley, and 10 of oats. The analysis showed 40 per cent of the samples to contain wild oats. The number ranged from a trace to 120 to the pound. Twenty-five per cent of the samples contained weed seeds other than wild oats. One sample was rather interesting. The farmer stated that he was planting the material for a sheep pasture; the analysis showed that oats was the predominating grain with a little wheat and barley, and in addition the following numbers of weed seeds to the pound:

- Witch grass: 1500
- Sweet clover: 1500
- Lamb’s-quarters: 150
- Wild oats: 45
- Small-flowered morning glory: 30
- Sunflower: 30
- Burdock: 15

Fig. 3.—Crop seeds are sources of dangerous weed seeds. At the left is clover seed free from weed seeds and at the right clover seeds infested with dangerous weed seeds. Which kind do you sow?
Here is seed being sown which contained wild morning glory seed, probably the most difficult of all weeds in Utah to eradicate. Farmers often purchase seed containing large quantities of impurities because they can get it at a reduced rate. A good example of such short-sightedness was a case that occurred in one county where a group of farmers got together, without consulting the county agricultural agent, and purchased a car of alfalfa seed, doing so because it was 8 cents cheaper than good seed. A sample of this seed was sent to the Agronomy Department of the Utah Agricultural Experiment Station for analysis. The analysis showed the sample to contain only 50 per cent alfalfa seed, the remainder being weed seeds. The number of weed seeds found in each pound of seed was as follows:

<table>
<thead>
<tr>
<th>Weed Seed</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamb's-quarters</td>
<td>138,243</td>
</tr>
<tr>
<td>Dodder</td>
<td>3,632</td>
</tr>
<tr>
<td>Tumbling red root</td>
<td>1,816</td>
</tr>
<tr>
<td>Erect pigweed</td>
<td>454</td>
</tr>
<tr>
<td>Curled dock</td>
<td>681</td>
</tr>
</tbody>
</table>

By sowing seed of this kind, at the rate of 12 pounds to the acre, the farmer sows enough dodder seed to allow one seed on each square foot of land. Such seed as this, which carries only 50 per cent alfalfa seed, would require twice as many pounds to be sown to the acre, thus bringing the cost of seed to the acre beyond that for good seed. In fact, this kind of seed is expensive at any price. Still another farmer brought a sample of seed to the department and wanted to know if it would be dangerous to sow that seed to thicken a stand of alfalfa. It contained about 40 per cent or less alfalfa seed, and the remaining seed, except for a few black mustard seeds, was cow cabbage.

These are only a few of the many examples of the grade of seed being sown on Utah farms. Is it any wonder that the weed menace is increasing in importance? Under present conditions with facilities so great for getting crop seeds analyzed, there is no excuse for planting seed without knowing what impurities it contains. It should further be emphasized that cheap seed is usually the most expensive in the end.

Man is also responsible for the introduction of weed seeds by means of farm machinery, especially the threshing machine. This is a dangerous source of noxious weed seed. Nursery stock, package material, hay, and commercial unground feeds are also bearers of troublesome weed seeds.

*Manure Often Carries Weed Seeds.* Manure often carries a great many viable weed seeds. Hay, bedding, and grain feeds may
contain large quantities of weed seeds which find their way into the
manure and are later hauled to the land. The common practice of
feeding unground mill screenings to chickens is also unsafe because it
is possible that the weed seeds not eaten will get back to the field in
the manure, in the bedding, or in both.

Experiments conducted in Maryland (19) show that weed
seeds present in manure can be killed by keeping the manure properly
piled. When various kinds of weed seeds were placed in piles of horse
and cow manure, both separately and mixed, only a few seeds were
alive after three months and none germinated after six months. This
indicates that a safe way to handle manure suspected of bearing
weed seeds is to keep the manure in a compact pile for a period of five
or six months, if possible, before scattering on the land.

Water as a Carrier of Weed Seeds. Too little attention is given
to the great number of weed seeds brought to the fields by irrigation
water. It is a common experience to hear farmers remark that they
have kept their fields free from weeds for a number of years, and yet
each spring there are just as many weeds as in previous years. In
many cases the agency by which these weed seeds were introduced was
irrigation water. Banks of irrigation ditches are usually grown up
with weeds which are permitted to ripen their seeds. These seeds
fall into the ditches and are carried to the field by the stream.

Experiments were conducted in Colorado (8) to determine the
importance of irrigation water in weed-seed dispersal. A device was
used to catch the seeds floating on the surface of the water. In 156
weed-seed catches, made on three different streams, a to-al of 81 dif-
ferent species of weeds was found. Those weed seeds occurring most
frequently were prostrate pigweed, erect pigweed, sedge, lamb's-quarters, tall marsh elder, knot weed, black bindweed, curled dock and
dandelion.

In Table 8 is given the estimated number of weed seeds of a few
common weeds, which passed a given point in a 12-foot ditch in 24
hours. A study of this table will give some idea as to just how im-
portant irrigation water is in carrying seeds.

Table 8 emphasizes the importance of irrigation water as an
agency in distributing weed seeds. The real solution to the problem
of preventing irrigation water from carrying weed seeds is to prevent
any weeds from maturing in places where they can get into irrigation
streams. This, however, is almost an impossibility, though the
danger could be lessened by preventing those weeds growing on ditch
banks from ripening their seeds. Some weeds will always be permit-
Table 8. Estimated number of a few of the common weed seeds passing a given point on a 12-foot ditch in 24 hours*

<table>
<thead>
<tr>
<th>Kind of Seed</th>
<th>No. of Weed Seeds Floating on a 12-foot Surface in 24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dandelion</td>
<td>10,355,904</td>
</tr>
<tr>
<td>Lamb's-quarters</td>
<td>1,302,912</td>
</tr>
<tr>
<td>Erect pigweed</td>
<td>1,280,448</td>
</tr>
<tr>
<td>Wild buckwheat</td>
<td>89,856</td>
</tr>
<tr>
<td>Curled dock</td>
<td>134,785</td>
</tr>
<tr>
<td>Marsh elder</td>
<td>157,248</td>
</tr>
<tr>
<td>Green foxtail</td>
<td>44,928</td>
</tr>
<tr>
<td>Sunflower</td>
<td>44,928</td>
</tr>
</tbody>
</table>

*Taken from Colorado Experiment Station Bulletin 253, p. 15.

...ted to seed out from the ditch banks. These seeds will fall to the ground or on the snow and many will be carried to the ditches by rain water or with drifting snow. Certainly, many of these weed seeds could be screened out of the water by inserting a series of three or four screens in the head-ditches where the water enters the field. A screen with large meshes could be used to catch the coarser material and one or two screens with finer meshes to catch the small weed seeds. Too fine a screen should not be used because of the difficulty of getting the water through. The screens could be installed in such a way as to be easily taken out and readily cleaned.

A machine has been invented which is claimed to remove all the seeds from irrigation water. If this is true, it will be of great value in helping to solve the weed problem. It can be installed at the head of an irrigation lateral entering the farm. The machine, depending on size, will carry a flow of water, from 2 to 200 inches. For the past two seasons it has been under test in various places in Idaho. Farmers who have installed the machine are cooperating with the Idaho Seed Commissioner's Officer with the aim of testing the effectiveness of the machine in removing weed seeds from streams. Deposits have been taken from several of the machines and analyzed. From one of the machines installed on a lateral to a farm near Caldwell, Idaho, a portion of the deposit was analyzed. The water carried to the field varied from 50 to 75 inches. The machine was run for 4 days after which a small portion of the deposit was removed, dried, and analyzed. One pound of dried material contained 147,780 weed seeds representing 26 different kinds. Seeds of all sizes were present, varying in number from 180 sow thistle seeds to 4050 bull thistle, 5850 water grass, 29,520 curled dock, and 48,510 pigweeds and lamb's-quarters combined.
Wind as a Carrier of Weed Seeds. Many weed seeds are especially provided with wings for wind distribution. Among these are dandelion, Canada thistle, bull thistle, sow thistle, prickly lettuce, and many others of the composite family.

![Dandelion in alfalfa](image)

Fig. 4.—Dandelion in alfalfa ready to have its seeds scattered by the wind. Poorly kept alfalfa fields are often over-run with this weed which materially reduces the hay yields. Timely cultivations with the spring-tooth harrow will help in the control of this pest.

About the only possible method of preventing seeds from being brought to the farm by the wind would be to prevent such weeds from producing seeds, and this necessitates cleaning up all waste places. Community cleanliness with regard to weeds is, therefore, essential to any far-sighted policy of weed control.

**Birds and Other Animals as Carriers of Weed Seeds.** Although some birds scatter weed seeds, birds as a whole are far greater benefactors as weed seed destroyers. Certain birds live almost entirely on weed seeds.

Farm animals often pick up certain weed seeds in their hair or wool or in the mud on their feet, and thus scatter them. These are of minor importance as compared with the other methods discussed.

**CLASSIFICATION OF WEEDS**

A common classification of weeds is that based on the normal length of time the roots remain alive and are capable of sending up new shoots. It is important to know the length of this period in order to wisely proceed to eradicate them. On this basis, weeds may be classified into (1) annuals, (2) biennials, and (3) perennials.
Annuals. Weeds which start growth from seed, grow to maturity, produce seed, and die are called annuals. In other words, the length of life is one year. The erect pigweed, probably the most common weed on cultivated land in Utah, stands preeminent to all other weeds in truck crops, orchards, beet fields and potato fields. Purslane is another weed which causes a great deal of trouble in trucking sections. The Russian thistle (so common in alfalfa fields), prickly lettuce, wild oats, sunflower, cockle, and several species of mustards are in evident competition with the grain crops; chickweed and crab-grass which are rapidly taking possession of lawns are also representatives of this class. Since this class includes many weeds with a wide range of adaptation, and since some weeds of this sort are found on every farm in Utah, it probably costs the farmers several times more to control annual weeds than it does biennials and perennials combined.

Biennials. These weeds live two years. They grow up from the seed the first year and produce a vigorous root system in which is stored a large quantity of reserve foods for the second year’s growth. The leaves (usually in a whorl) and the stems may die down in the fall of the first year, but the roots continue to live. In the second season, shoots develop from these live roots, and in summer or fall the plant produces seed, after which the life period is completed and the plant dies. This class is represented by common white sweet clover, wild carrot, burdock, bull thistle, and hound’s tongue.

Perennials. Those weeds living three years or more are known as perennials. To this class belong some of the most pernicious weeds—those most difficult to eradicate after once becoming established. Some of the most widely known and most feared weeds in Utah belong to this class. Among these are wild morning glory, whitetop, Russian knapweed, perennial sow thistle, and Canada thistle.

PRINCIPLES OF WEED CONTROL

Weeds can be controlled by observing rigorously three important principles:

(1) The prevention of weed seeds from being brought to the farm.

(2) The prevention of weeds from going to seed.

(3) The prevention of any growth above the ground (in the case of perennials.)

Control of Annual and Biennial Weeds. Annual and biennial
weeds are essentially alike in that they produce but one crop of seeds and then die. Since their only method of propagation is by seed, only two simply stated methods of control need to be observed: (1) to prevent the ripening of seed and (2) to avoid the introduction of seeds to the farm. While the control methods are simply stated, they are successfully operated only by the greatest vigilance. The methods of preventing weeds from ripening seed are many. Probably the most effective of all is cultivation. It is possible for the seeds of some of the weeds in these two classes to remain in the soil several years and then grow. Cultivation, therefore, should be continued as long as weeds continue to appear. In this connection, the farmer must pay careful attention to the carriers of weed seeds, for persistence of seeds in the soil is often blamed, when as a matter of fact it is due to irrigation water, manure, and crop seeds.

One interested in the control of weeds at a minimum cost should remember that weeds are most easily killed when in the young seedling stage. The spike-tooth harrow is very effective in weed eradication at this stage. If the weeds are allowed to grow beyond the seedling stage, plowing is necessary. A man with a team and harrow can kill in one day more weeds while they are young than eight or ten men and teams can if weeds are allowed to become large. Therefore, if necessary, the control of weeds should begin as soon as the crop is off the land in the fall. This applies to land constantly cropped with grain and where weeds become troublesome. The land should be handled in the fall, after the crop is off, so as to induce the weed seeds, that have ripened and fallen, to germinate. Irrigation and disking may be necessary; however, deep plowing should not be practiced as it turns under many weed seeds that will remain dormant in the soil. These weed seeds will not germinate until plowed to the surface again. The time required to eradicate them is thereby delayed. Plowing, however, does turn under a great many seeds that die before they are again returned to the surface. The extent of this depends on the kind of weed seeds. Many of the seeds that are induced to germinate in the fall will winterkill, whereas some will survive the winter and may then be killed by cultivation before the crop is seeded in the spring.

The fact that certain annuals start growth in the fall, live over winter, and seed early the next season, while others may germinate in the fall and be killed by the winter or may not germinate until spring, divides this class into what are known as winter and summer
annuals (or merely annuals). These groups correspond to winter and spring wheat.

If weeds are likely to be troublesome in beet and potato fields or in any other cultivated field, it is a good practice to prepare the seedbed very early to induce weed seeds to germinate in order that they may be killed with a harrow before planting. Often, if weeds are difficult to control, it is advisable to delay planting in order to kill the weeds before the weeds destroy the crop.

In lands where it is impossible, or difficult, to cultivate, such as in sod pasture or along fence lines or ditchbanks, mowing, grubbing, burning, or spraying may be necessary to prevent seeding. Certain weeds along ditchbanks and fence lines may be pastured to good advantage, especially by sheep.

The winter annuals, being much like winter wheat in habit of growth, become difficult to control when found in winter wheat. Where summer-fallowing is practiced these weeds are easily controlled by keeping the fallow clean, but where continuous cropping is practiced the problem is very different. Here is the condition in which these weeds are likely to become most troublesome. Under such conditions a rotation that includes an intertilled crop must be adopted, if possible; otherwise, summer-fallowing must be practiced often enough to keep weeds in check. In the Dakotas, an iron sulfate spray has been used with considerable success to control many of the common weeds found in grain fields. This spray, however, will not control wild oats or other grass-like weeds.

**Control of Perennial Weeds.** Perennials, as stated, live from year to year without starting again from seed. They propagate themselves either by seed or by vegetative means, or by both. It is important, therefore, not only to prevent seeding but also to prevent the plant from making any growth above the surface of the ground. The weeds in this class may again be subdivided into two groups, depending on the nature of the rooting system. The one group produces underground stems or rootstocks from the buds of which new plants develop, and the other group produces a rather fleshy tap root similar to that on alfalfa, much enlarged at the surface, from which new shoots arise each year. These enlarged portions, by virtue of which the plants live, are called root crowns.

**Weeds Developing Underground Stems or Rootstocks.** Many of the weeds of this group are pernicious on account of their underground stems. These underground stems grow out parallel to the surface of the soil. They are usually within a few inches of the sur-
face, though they may penetrate deep into the soil if conditions are favorable. They possess the power of sending out new shoots and roots at intervals. In one year several plants may arise from a single underground stem. If these underground stems are broken during cultivation, they may be carried to uninfested soil and become a source of new infestation. The primary function of these underground stems is to reproduce the plant and to act as a storage reservoir for plant-food. An old patch of morning glory will fill the soil completely with underground stems which contain great stores of reserve food materials. Any method of control for such weeds, therefore, must have as its object (unless the plant is poisoned outright) the complete exhaustion of this reserve food supply. When possible, this is best accomplished by frequent cultivations. Conditions should be made so favorable for the weed that it will make a rapid growth, since in so doing new shoots are immediately sent up after each cutting, and these draw on the reserve food supply. It is very important that these shoots be cut off before or as soon as they reach the surface of the ground. Cuttings should be continued until all the reserve food is exhausted, as evidenced by the failure of new shoots to appear. If shoots be allowed to reach the surface of the ground and remain for any period of time, food is manufactured in the green leaves, and some of this food is translocated into the storage reservoirs in the underground stems. The plant then begins to replenish the food supply, thus prolonging the time required for its eradication. These underground stems may be likened to an individual's bank account. One deposits $100 in the bank and draws out $10 each month for 10 months and the supply is exhausted: but if one draws out $10 the first month and deposits $2 before drawing out the $10 the second month, and continues to do this it will take more than 10 months, to exhaust the supply in the bank. This $2 deposit is analogous to allowing the weed to make some top growth between cultivations. If intervals between the cultivations are prolonged, food will again be stored to make up for that used in developing the new shoots, and the plant may become as strong as ever. Thus, the energy in making the first cultivation is wasted. Another fact of considerable importance is that individuals have worked constantly at keeping one or another of these obnoxious weeds down during the summer, but toward late fall they have discontinued their operations and the plant makes vigorous top growth. The farmer wonders why the weed appears again the next season. It is similar to the bank account analogy. An individual has drawn on his deposit all sum-
mer, but toward fall he makes another deposit to draw on during the following spring. The plant does likewise. The food supply has been drawn on all summer by keeping it cultivated, and, toward fall by permitting the plant to make a top growth a re-deposit of food was made into the underground stems. In view of this it is important to begin the work of control early in the spring as soon as any growth is visible and continue the operations into the fall as long as new shoots appear. To exhaust the food supply of certain well-established perennials, such as morning glory, is a long and tedious task, but those who are really serious about their control can accomplish it. However, it requires patience, persistence, and unrelenting vigilance.

Weeds with Root Crowns. The other class of perennial weeds includes all of those which do not produce underground stems and which, therefore, do not spread underground. Such weeds as dandelion, curled dock, and chicory are of this sort. Weeds of this group are not nearly so difficult to exterminate as that group which produces underground stems. The main root is usually fleshy and acts as a storage reservoir for food in addition to possessing other functions. New shoots develop from the crown of these fleshy roots from year to year, thus making them perennial in nature.

Cutting them well below the crown will usually kill the plant, though this is not always true. Since these weeds cause very little trouble in land that is frequently cultivated, badly infested land, therefore, should be put under cultivation. Lawns, pasture, and hay fields suffer most from this class of weeds. Badly infested pastures and hay fields should be plowed up and seeded to a cultivated crop. Alfalfa fields, and especially old fields, are frequently over-run with dandelion. The old fields should be plowed up, seeded to an inter-tilled crop, but young fields may be largely freed from dandelion by the vigorous use of the spring-tooth harrow.

METHOD OF PREVENTING WEEDS FROM PRODUCING SEEDS OR ELIMINATING TOP GROWTH.

The secret of weed eradication is to prevent the production of seeds and the development of any top growth. A knowledge of this suggests the question often asked by farmers: What is the best way to prevent weeds from making any top growth? It is difficult to give an answer to the question which will cover all conditions because one method might work under certain conditions and not be applicable under others. From the standpoint of the farmer, no doubt,
cultivation and crop rotation is most nearly the correct answer. Other methods have been recommended, and they have met with some success under some conditions. Those most commonly advocated, in addition to cultivation and crop rotation, are as follows: treating with chemicals, smothering, flooding, pasturing, burning, and digging.

Chemicals. Various chemicals have been used in the eradication of weeds. Those most often used are common salt, iron sulfate, blue vitriol, sodium arsenite, carbolic acid, kerosene, crude petroleum, sulfuric acid, caustic soda, corrosive sublimate, carbon bisulfate, and sodium chlorate.

Common Salt. This has been used to considerable extent in weed control. It is inexpensive, except for large areas, and is effective if properly applied. The chief drawback is the fact that when used in sufficient quantities to kill weeds it destroys all other vegetation. Its use, therefore, is limited to areas where land is not wanted for cropping. Salt is now being used in Idaho to some extent in the control of noxious weeds. Experimenters there recommend from $\frac{3}{4}$ to $1\frac{1}{2}$ pounds of salt to the square foot, depending on the weed. It is applied in the dry condition. The crushed rock salt, or ice cream salt as it is commonly called, is preferable.

Experiments were conducted at Hays, Kansas (6), on the effect of different quantities of salt on field bindweed, or morning glory. One-tenth-acre plats were salted at the various rates of 8, 12, 16, 20, 24, and 28 tons of salt to the acre. The salt was applied between June 27 and July 1, 1919. At the close of the season the plats showed the following results (on one-tenth-acre plats) for the various rates of salting:

28 tons of salt per acre—no plants left
24 tons of salt per acre—5 or 6 weak plants
20 tons of salt per acre—5 dozen plants
16 tons of salt per acre—15 per cent of the plants left
12 tons of salt per acre—40 per cent of the plants left
8 tons of salt per acre—75 per cent of the plants left

Iron Sulfate. This chemical is a by-product of the iron and steel industry, and is comparatively cheap. It is used in the form of a spray applied in a very fine mist. It is best applied on a clear, warm day when it is not likely to rain. One formula recommended (9) is: 100 pounds of iron sulfate to 52 gallons of water. It requires about this amount to cover an acre of herbage. This spray has been
used successfully in the northern plains states and some of the eastern
states for killing plants with rather broad-veined leaves (not narrow,
parallel-veined leaves like the grains). It was used to control such
plants as mustard and cockle in grain fields, and dandelions and
chickweed in lawn. It must be kept in mind, however, that it will
not kill such weeds as quack-grass or crab-grass.

Experiments carried on in South Dakota (18) on the use of
iron sulfate as a spray gave the results as shown in Table 9.

Table 9. The effect of a 20 per cent solution* of iron sulfate on various
weeds when applied in a fine mist.

<table>
<thead>
<tr>
<th>Weeds Entirely Killed</th>
<th>Weeds Badly Injured</th>
<th>Weeds Just Slightly Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild mustard</td>
<td>Russian thistle</td>
<td>Plantain</td>
</tr>
<tr>
<td>Ragweed</td>
<td>Sunflower</td>
<td>Sheep sorrel</td>
</tr>
<tr>
<td>Kinghead</td>
<td>Dandelion</td>
<td>Prairie rose</td>
</tr>
<tr>
<td>Marsh elder</td>
<td>Dock</td>
<td>Lamb's-quarters</td>
</tr>
<tr>
<td>Milkweed</td>
<td>Thistle</td>
<td>Grasses</td>
</tr>
<tr>
<td>Pepper grass</td>
<td>White clover</td>
<td>Small grains</td>
</tr>
<tr>
<td>Pigweed</td>
<td>Red clover</td>
<td></td>
</tr>
<tr>
<td>Sweet clover</td>
<td>Alfalfa</td>
<td></td>
</tr>
</tbody>
</table>

*100 lbs. iron sulfate in 50 gals. water.

Another experiment (16) in Wisconsin with iron sulfate gave
complete control of wild mustard in grain fields with a 20 per cent
solution applied in a fine mist at the rate of 52 gallons an acre.
During this same test they report practically complete control of
cocklebur, ragweed, dandelion, daisies, and wild lettuce. It cost about
$1.25 an acre for materials and labor in applying.

At the New York State Experiment Station (Geneva) (17)
iron sulfate has given very satisfactory results in the control of
dandelions in lawns. In addition, common chickweed, purslane, and
yellow trefoil were killed after repeated sprayings; wild geranium and
mallow were badly injured; wild geranium and
mallow were badly injured; broad-leaf and narrow-leaf plantain
and curled dock were either killed or badly injured; knot-grass and

crab-grass were either uninjured or only slightly injured.

Four or five sprayings each season were necessary. Sprayings
should begin in May before the dandelion blooms and applied at
intervals of three or four weeks during the summer and once or twice
before frosts. The spray is made by mixing 1.5 pounds of iron sul-
fate in 1 gallon of water and the solution applied as a fine mist. One
gallon will cover about 375 square feet. The spray should not be
applied so heavy as to drench any part of the plants because of the
danger of injury to the grass. It is best to apply the spray during
clear, bright weather when the soil is moist. Any white clover pres-
Fig. 5.—In New York state, dandelion in lawns can be controlled by spraying with a solution of iron sulfate. The area free from dandelion was sprayed with iron sulfate. (New York State (Geneva) Expt. Sta. Bul. 466).
ent in the lawn will likely be killed, and the grass will darken after each spraying but will soon recover. It is necessary to reseed and fertilize after the dandelions and other weeds are killed.

**Blue Vitriol or Copper Sulfate.** This material is used as a herbicide as well as a fungicide. It is used in treating grain to prevent covered smuts and is also used as a spray for killing weeds. The formula recommended (9) is 8 to 12 pounds of copper sulfate dissolved in 52 gallons of water. The solution is used similarly to that of iron sulfate and is recommended for about the same conditions. However, it is not so generally used as a herbicide as is iron sulfate.

**Sodium Arsenite and Commercial Weed Sprays.** Sodium arsenite is a violent poison and should be handled with care. Animals should be kept away from weeds sprayed with it because its brackish sweet taste attracts animals, and poisoning is likely to occur. The soil may also be temporarily injured by its use. The chemical is rather effective in killing plant tissue with which it comes in contact with the possible exception of plants with waxy and leathery leaves. Spraying the portion of the plants above ground does not result in its being carried down to the roots or tubers of plants; therefore, successive sprayings are necessary to keep down vegetative growth.

Gray (11), however, in experiments conducted in California along the coast in the fog belt where the air was humid, found that a spray solution killed 85 to 95 per cent of the roots to a depth of four feet. His spray consisted of 10 pounds of granulated caustic soda (98 per cent) and 20 pounds of white arsenite (As²O³) (99 per cent) in 5 gallons of water, diluted at the rate of one gallon of this stock solution in 99 gallons of water. Sprayed fields appeared to be free for eight to 12 months, after which new shoots came to the surface. He thought that annual fall spraying would eventually eradicate the weed under moist atmospheric conditions. Further experiments (3) conducted in California led to the conclusion that sodium arsenite could not generally be recommended for the control of morning glory outside the fog belt.

There are several grades of commercial sodium arsenic solutions on the market (25), and these vary greatly in strength. Some contain the equivalent of only 1 or 2 pounds of white arsenic to the gallon, while others contain as much as 8 pounds to the gallon. This material may also be obtained in the powdered form. In this form it is used at the rate of 1 pound of sodium arsenite to 3 to 9 gallons of water. The formula recommended for material with an equivalent
cf 8 pounds of white arsenic to the gallon is to use one gallon of the commercial solution and dilute with 40 or 50 gallons of water.

Sodium arsenite is the killing agent in most commercial weed killers. Directions for use of these weed killers usually accompany the materials. A weed killer, known as K.M.G. (Kills Morning Glory), with arsenic chloride as the foundation substance, has been reported in California (13) to have killed morning glory roots down 6 feet when applied on the portion above ground.

Carbolic Acid (Phenol). This material can be used only on small areas because of the cost. It is effective in killing weeds, especially along paved walks or courts and other places where no vegetation is desired. It is used at the rate of 1 quart of carbolic acid in 8 gallons of water. This quantity is sufficient for 1 square rod.

Kerosene and Crude Petroleum. Both of these have been used to kill weeds with varying success. Where large quantities of cheap materials are available, such as in parts of California near the oil fields, waste oil or petroleum may be used to advantage in saturating ditch-banks and fence lines to prevent weed growth. This would be especially advisable in the case of noxious perennial weeds, and at the same time it would help to prevent water losses from seepage. By adding sufficient of these materials to kill weeds the soil is made sterile for other crops and remains so for some time. On this account their use is very limited.

Sulfuric Acid. This chemical is very difficult to use and must be handled largely in glass containers. It is highly destructive to clothing, and if it comes in contact with the hands may cause a serious burn. It is usually applied directly to the plant in the form purchased. Recent experiments reported from Sweden (5) show that a 3 to 4 per cent solution of sulfuric acid has proved more effective in controlling weeds in grain fields than has a solution of iron sulfate, sodium nitrate, salt brine, or dusting with weed powders.

Caustic Soda. This material when applied in a strong solution kills all the vegetation and, therefore, is not adapted to general use. It is considered to be more effective than carbolic acid for killing poison ivy and any other woody and deep-rooted plants. It is best to apply it in strong solutions during dry, hot weather.

Corrosive Sublimate (HgCl₂). This chemical is also used in treating potatoes for various diseases. It is very poisonous and care, therefore, should be exercised in its use. It is expensive and is not
recommended for general use in weed control. When used, a solution is made by dissolving 1 ounce of the chemical in 6 gallons of water.

**Carbon Bisulfide.** This chemical is a highly explosive, volatile liquid, and because of this great care must be exercised to keep it away from flames or electric sparks. It is not used as a spray but is poured into holes in the soil; consequently, it cannot be used without the sacrifice of the soil during the season of treatment, nor could it be used in orchards without danger to the trees. Its use is also limited to small areas because of the cost. In Idaho the cost is estimated at from $150 to $200 an acre when used to eradicate morning glory. Carbon bisulfide as a weed eradicator has been used in extensive tests in California (3) where it was found to be effective in eradicating morning glory. On account of the cost, it has been recommended only on small patches or where cultivation was not practical. Holes about 3 feet apart each way and 18 inches deep were made over the entire area covered by the weed. Into each hole was poured 4 ounces of carbon bisulfide, after which the hole was again filled with soil. These tests indicated that the work should be done when the soil is rather dry.

This material has since been used in several other states with fair success. When first attempted in Idaho (2) and used as recommended in California, the results were not as favorable as had been expected, but after some experience they finally secured good results by placing 2 ounces of the chemical into holes bored 18 inches deep and 2 feet apart each way. The top of the hole was sealed by tramping with the heel. Idaho results indicate that the treatment should be applied while the soil is moist. This is contrary to conditions which gave best results in California.

In Utah, carbon bisulfide has been used to some extent as a weed killer. Not in all cases has it given complete control. The kind and condition of the soil and moisture-supply are possibly important factors in determining the success of the treatment with this material. The moisture supply is no doubt an important factor, and it has been the experience in Utah that killing was secured best when the soil moisture occupied about 25 per cent of the pore space. It has been used in dry soil in a few cases where it has given unsatisfactory results. Still other unfavorable results are thought to be due to the holes being too far apart, not deep enough, or insufficient chemical used. More experimental work in this section is probably necessary before any exact recommendation can be given; in any case, its cost will probably prohibit its use except on small patches.
Sodium Chlorate. From recent reports this chemical gives promise of becoming a very important means of controlling pernicious weeds, at least in some sections. In a preliminary report on the use of sodium chlorate on the control of Canada thistle, Aslander (1) has obtained very encouraging results.

Plots on which the weed was growing were sprayed on November 11, 1925, after a frost had killed the tops. To determine the extent of killing, data were taken the following June. A 10 per cent solution was used and applied at various amounts, namely, 107, 161, 214, 268, and 331 gallons an acre. These various rates of treatment on a plot 4 meters square reduced the number of Canada thistle shoots from an average of about 44 to 5, 3, 3, 0, and 0 for the respective treatments. Similar results were obtained with potassium chlorate.

More recently sodium chlorate has been reported in Kansas (14) to have given very good results in the eradication of wild morning glory. A 12.5 per cent solution was made and applied in the form of a spray. Three sprayings were sufficient to eradicate the weed. The first spraying was applied when the plant was in full bloom.

Recent reports from Idaho on the use of sodium chlorate are not so favorable.* The short season made it impossible to make more than two sprayings, and these sprayings gave unsatisfactory results. It was felt that because of the expense at the rate used as well as the uncertainty of control, there is little likelihood of sodium chlorate being of great value under Idaho conditions.

Smothering. The smothering of weeds as a means of eradication has been attempted in two general ways, namely, by the use of a smother crop, and by the use of some non-living material such as manure, straw, leaves, tar paper, etc., which would shut out the light and as much of the air as possible.

Smother Crops. Smother crops are those that produce a thick, rank growth of vegetation, and thus crowd out the competing weeds. The crops most useful in this region for this purpose are alfalfa, sweet clover, small grains, corn, and Russian sunflower, and possibly Jerusalem artichokes. These have all been used in the control of weeds, and in some cases have been effective. Some individuals have obtained control of morning glory by crowding with alfalfa. To do this, however, conditions must be ideal, with the soil and moisture supply very favorable and other conditions such that it is possible to get a good stand of alfalfa before the weeds get well

*Private correspondence with H. W. Hulbert, Agronomist, Idaho Agricultural Experiment Station.
started in spring. In California, according to Barnum (3) the Spreckels Sugar Company found that alfalfa was the best, most economical, and at the same time the most profitable method of control where conditions were suitable for the crop.

Farmers have reported satisfactory results in controlling pernicious weeds by the use of a heavy growth of wheat or oats. On account of their more rank growth, oats would probably be the better of the two crops for this purpose.

In Utah County some farmers have secured satisfactory results in controlling whitetop on irrigated land by plowing late in the spring followed by a heavy seeding of wheat or oats. This treatment might control whitetop because it makes its growth early in the spring and toward late spring or early summer gives little trouble. Morning glory, however, is not likely to succumb to this treatment.

Corn and Russian sunflower have been tested at the Utah Agricultural Experiment Station (27) in controlling morning glory. In one year's treatment both crops weakened the morning glory considerably, though did not eradicate it completely. The Russian sunflower appeared to be more effective than the corn.

Jerusalem artichokes have been recommended as a smother crop
for weeds. However, the nature of the plant is such that it may become a fairly troublesome pest itself. The plant produces fleshy underground roots somewhat similar to a potato tuber, though the latter is a stem and not a root. These roots, unless removed from the soil, continue to send up new shoots each year; thus the plant becomes essentially perennial in its nature. This crop has been used largely as a source of feed for hogs. With this in mind possibly land infested with weeds producing rootstocks, or others for that matter, could be used to good advantage by planting to artichokes and pasturing with hogs.

Smothering by the Use of Non-living material. Smothering weeds by the use of manure, straw, leaves of various kinds, beet pulp, pulp from tomato canneries, and tar paper have all been tried in the control of rootstock perennial weeds.

Manure and straw are probably the most widely advocated means of controlling weeds by this method. Favorable results in the control of morning glory on small patches by the use of manure or straw have been reported from Idaho (2). They recommend that the patch be covered with straw or manure, which is then wet down to form a compact mass a foot in depth and as new shoots appear cover them with similar material. They state that the aim in this treatment is to kill by excluding the air from the plants, and this is best accomplished by wetting and tramping down the material used. Manure and straw (3) have both been used in the control of morning glory in California, but with very unsatisfactory results. Where manure was piled to a depth of 6 feet morning glory is reported to have appeared in a short time and flowered.

At the Utah Agricultural Experiment Station straw was piled on a patch of morning glory to a depth of 8 feet and the plants grew up through the straw. The use of leaves for smothering would be about as effective as straw and has met with about equal success. Beet pulp and pulp from tomato canneries have been used as a means of smothering weeds. In California, beet pulp piled on the soil 6 inches deep over a morning glory patch failed as a means of control. Such materials could be used only on small patches and the covering would have to be rather thick and wet.

Tar paper has been used with good results in the control of whitetop and of perennial sow thistle in small patches. It is rather costly but effective if properly done. Its use as a control for morning glory has not been too satisfactory chiefly on account of the morning glory's growing out from beneath the laps. This could probably
be prevented by nailing the paper to small strips of wood. Experiments reported from Colorado (22) on whitetop gave complete control by the use of tar paper nailed to small strips of wood. This prevented the plant from sending out shoots to the light. Tar paper, if used should be applied with the aim of shutting out as much light as possible by placing the paper close to the surface of the ground. The weeds on the infested area should first be cut and ground leveled. The tar paper, or other similar material to be used, should be placed as snug to the ground as possible. The paper should extend several feet beyond the weed patch with each strip either nailed to a small strip of wood or allowed to overlap 8 to 10 inches and covered with dirt or sod. In Saskatchewan (29), Canada, in the control of perennial sow thistle it is recommended that the tar paper be covered with a layer of sod laid closely together, and over this 2 or 3 inches
of fine loose earth. This covering must sometimes remain in place two years, but often one year will kill the weeds.

Flooding. This method of controlling weeds is restricted almost entirely to a special soil condition which makes it possible to maintain a layer of water constantly over the entire patch of weeds. A dike should be built around the weed patch out about 10 feet from the outer edge. Water is then applied in sufficient quantity to cover all vegetation and keep it covered for a period of six weeks or more. This method has met with success under favorable conditions where it was possible to maintain the water cover.

Pasturing. One valuable method of keeping many weeds from seeding along ditchbanks and other waste places is to pasture. Sheep or goats are the most valuable animals for this purpose. Sheep, if allowed to pasture whitetop, are very effective in preventing its seeding, and often they pasture it so close to the ground as to weaken it materially if not actually to kill it out. Hogs have been used with a fair degree of success. They are allowed to pasture on the

Fig. 8.—Irrigation water is an important agency in carrying weed seed to the farm. Note the difference in the prevalence of weeds and other plants on the grazed and ungrazed sides of the stream. Pasturing to keep down weeds along ditch banks and other non-cultivated areas is an effective means of turning otherwise undesirable plants into a product of money value (meat and wool). (Photo by Ackerman, U. S. D. A.)
WEEDS

rootstocks of such plants as morning glory and whitetop. The weed patch should be fenced and the field plowed prior to turning in the hogs as well as at intervals throughout the season so as to expose as many of the rootstocks as possible. On well-drained soil where the roots may penetrate to great depths, it is doubtful if the hogs will be very effective in the control of morning glory.

Experiments conducted at the Utah Agricultural Experiment Station by the use of hogs in eradicating morning glory disclosed the fact that they were effective in reducing the amount of rootstocks to about 10 per cent, thus partly keeping the weeds under control, but they failed to eradicate any patches.

_Burning._ Burning is a very feasible method of eradicating small patches of certain weeds, such as dodder. Annuals and biennials should be cut before they have seeded, but if they are allowed to blossom or the seed to form before they are cut, many plants will mature their seeds after they are cut. Consequently, such plants should be burned as soon as possible after cutting.

A few patches of dodder in alfalfa are quite easily eradicated by burning. The pest usually appears in a few circular areas in the field. These areas, and a distance of several feet beyond them, should be cut before seeding and burned. Straw, oil, and other combustible materials have been used on such spots to insure complete destruction of the dodder. After burning, these patches should be examined during the summer, and if new seedling plants appear they should be hoed out. Alfalfa may again be seeded on the burned spots the following spring. Mowing and burning along ditchbanks, highways, waste places, etc. is a very effective way of preventing weeds from seeding. In addition, many undesirable insect pests are destroyed.

_Digging._ Digging out weeds as a means of control is a very laborious task if attempted on a large scale, though in lawns where only an occasional dandelion or other unsightly weeds appear, they may be dug out and destroyed. In pastures bull thistle is rather easily controlled by cutting the plants well below the crown. A sharp-pointed shovel or spade is useful for this purpose. Whitetop, morning glory, and many other troublesome perennial weeds could have been eliminated from some farms with little effort if they had been dug out and destroyed when they first appeared. An individual in Cache Valley has in the past few years permitted several acres of his farm to become infested with whitetop because he failed to dig out and destroy a small patch when it first appeared.
of trouble in grain fields, while they seldom occur in grass and cultivated crops. Still, the weeds common in grass crops, such as ragweed and bull thistle, for example, seldom occur in cultivated crops. In fact, in any system of crop rotation, where various types of crops are in use, there is a gradual change in the weed population with a change in crops. From this it is obvious that a rotation of crops is a very effective means of controlling many of the most troublesome weeds.

**Cultivation.** Where cultivation can be practiced it is possibly the surest and most effective and widely practiced method for the eradication of weeds. The plow, the harrow, and various kinds of cultivators, the rotary rodweeder, and many other special devices have been used in destroying weeds. The implement to be used is the one which does the job best at the least cost. It is likely that an implement which covers a comparatively wide area of ground is the most economical. Not always, however, are such implements especially devised to kill weeds unless the weeds are small, and this suggests one of the most important principles in weed control, and this is to kill the weeds while they are as yet mere seedlings. The harrow, an implement practically worthless for the eradication of old weeds, is very effective on seedlings. One man, by means of two double-section harrows and four horses, can kill innumerable young weeds in one day, whereas if the same lot of weeds were allowed to go two or three weeks and obtain any appreciable size it would require days or even weeks to do the job. Practically any weed, whether annual, biennial, or perennial, is killed with equal ease if the work is done in the seed-

**Fig. 10.**—Growth of morning glory the following June after a season of the following treatments: Immediate foreground: Spray delayed until full bloom followed by shallow frequent tillage, infrequent tillage (note the presence of some weeds), sunflowers for smother crop, and the repetition of spray treatments.
ling stage. If perennial weeds, such as morning glory, whitetop, or any other weed which produces rootstocks, get well established, the problem of eradication is made many times more difficult.

Any weed, regardless of how persistent it might be, can be eradicated by preventing the plant from making any growth above ground: where possible, usually the best method of doing this is cultivation. Any weed can be controlled by cultivation if it is done often enough and continued for a sufficiently long period of time. Morning glory, whitetop, Canada thistle, Russian knapweed, and quack-grass are all conquered by this same treatment. Some require more of such treatment than others. The eradication of troublesome perennials by this method should be planned with the aim of exhausting the food supply in the underground stems or rootstocks. This can be accomplished by preventing any growth to appear above ground; at the same time the surrounding conditions should be made favorable for plant growth. Irrigation water should be applied if necessary, because the quicker new growth occurs the sooner the reserve plant-food stored in the roots will become exhausted. Rapid growth of a weed means a shorter time required for its extermination.

On badly infested areas a crop should not be grown, at least for the first year. If the ground is hard plowing will first be necessary, after which a good type of cultivator should be used that will cut all the plants. It is not necessary to cultivate deeply, though possibly by deeper cultivation it would take a longer time for new shoots to reach the surface; hence, cultivation need not be so frequent.

At the Central Experimental Farm at North Logan (Greenville) (27) it was found that by cultivating sufficiently frequent to prevent the morning glory from making any top growth, this weed, entirely covering a field, was so weakened in one season that only an occasional plant appeared the following spring. The remaining plants were easily removed from a thrifty crop of sugar-beets. Farmers in different parts of the state have reported the complete eradication of morning glory by cultivation. Cultivation experiments conducted in California (3) on morning glory gave satisfactory control by frequent rather deep cultivations. The period between cultivations should not be greater than five days. The important principle here is to prevent any growth from appearing above ground. Cultivation should be given every three or four days if necessary. Numerous experiments have been conducted at various places in the United States on the control of the most pernicious weeds, with the rather uniform conclusions that cultivation is one sure method of complete eradica-
tion. It may take one, two, and in some cases three years, but it can be done.

DISCUSSION ON METHODS OF CONTROLLING WEEDS

From a consideration of the foregoing methods of controlling weeds, it is apparent that the solution to the weed problem is intimately connected with the adoption of a better system of farming. It is the problem of every farmer to adopt a system of farming that will give him high acre-yields and at the same time keep weeds in check. He who expects the farm to pay cannot hope to solve his many problems one at a time. A great many of his production difficulties are associated with poor farm practices. Disease, insect control, and the weed problem are largely one, the solution of which is largely the adoption of better farm practices. Crop rotation and timely cultivations are effective methods in combatting weeds.

CONTROL OF WEEDS UNDER SPECIAL CONDITIONS

The constant struggle with weeds on land that is continually being used for crop production is an extremely vexing problem, but the farmer must not neglect this if he expects to get any appreciable yields. The problem, however, of controlling weeds on ditchbanks, fence lines, highways, and waste places where the farmer feels that he does not get anything in return for his efforts is an even more perplexing problem, though one in which he should be vitally concerned, as such places are constant breeding grounds of weed seeds, many of which ultimately reach the farm. One small waste corner in a field, if allowed to grow up to weeds, will produce enough seed to reseed the entire farm. Likewise, weeds that are permitted to go to seed along ditchbanks drop their seeds into the stream and are carried to the fields. Though the farmer may feel that his efforts are wasted by preventing weeds in such places from seeding, it is in reality not so because the work necessary to keep weeds in check on cultivated ground would be much lessened.

On Ditch Banks. The fact that irrigation water is such an important carrier of weed seeds makes it all the more important that weeds be kept under control along irrigated ditches. The first principle of control is to prevent any weeds from seeding along ditchbanks. By so doing annuals and biennials will cause little trouble as far as the cultivated ground is concerned, but perennials, especially those which
Fig. 11.—Solving the weed problem along city highways. Compare with Fig. 12. Streets grown up to weeds are often sources of dangerous weeds as well as being unsightly and also fire hazards. (Utah Agr. Ext. Serv. Cir. 4.)

Fig. 12.—The same street as in Fig. 11 after being planted to harmless beautifying plants in contrast to dangerous and unsightly weeds. (Utah Agr. Ext. Serv. Cir. 4)
produce rootstocks, if not completely eradicated, will spread to the cultivated ground. They creep out from the ditchbanks, when the soil is tilled, and rootstocks are broken off and carried to non-infested soil. Pieces of rootstocks left lying in ditches after cleaning are frequently carried to the cropped land by irrigation water. Since these rootstocks have the power of developing new plants, sooner or later the weed occupies the entire cropped area.

Under such conditions, weeds can be prevented from seeding by pasturing, by mowing, by burning, or by treating with some chemical. Sheep are very effective in keeping down weeds along ditchbanks.

Fig. 13.—The solution to the weed problem is not a one-man proposition. It calls for community action and neighborly cooperation. A ditch which separates two farms. On one side the farmer has mowed the weeds to keep them from seeding, while his neighbor has shirked his responsibility by not keeping the weeds down on his side of the ditch. (Colo. Agr. Expt. Sta. Bul. 253)

However, if sheep are not kept on the farm, mowing and burning should be practiced. Chemicals might also be used, though the cost will prohibit their use on any large scale.

Pernicious perennial weeds such as morning glory, whitetop, and Canada thistle, on ditchbanks should be completely exterminated. This can be done either by frequent hoeings, by the use of carbon bisulfide, or by salt. The larger ditch and canal banks may be constructed in such a way as to permit cultivation. Ditchbanks are ideal places for plants to grow, and to keep them free from vegetation is almost out of the question, especially on the longer permanent
ditches: however, very often it is possible to change the type of vegetation from that of weeds to that of some useful or non-dangerous plant. Such plants as blue grass, brome grass, or alfalfa might be used for this purpose. This would help solve the weed problem and at the same time supply considerable forage.

Along Public Highways and Railroads. It is almost impossible for a farmer to keep his field free from weeds if the highways bordering his farm are allowed to grow up to weeds. For any county to attempt to eradicate all the weeds along its highways would cost more money than is received in taxes. Such an attempt would be almost an impossibility. Some of these weeds are of little consequence to the farmer. About the only thing that can be done is to prevent from seeding those weeds which may cause trouble to the farmer. Cutting, with either the mower or scythe and in the case of a few weeds grubbing, would adequately take care of annuals and biennials. The more pernicious perennials, however, should be kept from spreading to cultivated fields. The best method to use would depend on the conditions. Cultivation, salting, crude oil, or carbon bisulfide

Fig. 14.—In the farming sections much of the untilled land, such as occurs along public highways, railroads, waste places, and canal banks, might profitably be planted to a harvested crop and thereby help solve the weed menace. (U. S. D. A. Farmers' Bul. 660)
might be used to advantage. Much of the land along railroads and public highways could be put under cultivation and seeded down to some crop which would thereby help solve the weed menace.

In Waste Places. Waste places are an ever-annoying source of weeds, being unsightly as well as a source of danger not only from weed seeds but insect pests and diseases as well. Weeds are allowed to grow up around corners of irregular fields, on small areas of ground around the farmstead, in vacant lots and innumerable other places; and in a short time become the most conspicuous spot on the farm. Bull thistle, cocklebur, ragweed, and many others thrive in such places. Often these waste places are the actual source of dangerous weeds, because it is here where the rubbish is dumped and frequently weed seeds or portions of bad weeds are present in the material. Unmolested, they get a good start before being noticed. Many of these places could be put under cultivation, others could be pastured with sheep while the vegetation is young. Still other places should be mowed to prevent weeds from seeding. Dangerous weeds should be exterminated.

SUMMARY

Weeds have become serious in Utah, as a result of which farmers suffer vast losses each year. These losses occur in several ways: (1) By decreasing crop yields, (2) by decreasing the unit value of both crop and dairy products, (3) by injuring stock from poisoning, (4) and by harboring insects and diseases.

Weeds are usually more hardy than crop plants because of some effective means of adaptation that they possess. Therefore, they are able to crowd out crops with which they compete; consequently, they flourish. Some of the means by which weeds survive are:

1. Some weeds have the ability to produce large numbers of seeds.
2. The seeds of some weeds resemble the crops in which they occur.
3. Some weed seeds will remain dormant for a period of time before germinating.
4. A few weeds develop thorns, burs, or spines on either the leaves or seeds. If on the leaves the plants are not grazed and, therefore, are permitted to ripen their seeds; if on the seeds the seeds lodge in the hair or wool of animals and are thereby disseminated.
5. The development of root stocks or underground stems which represent a vast reserve of energy, from which new shoots continue to
grow.

Since one of the important principles of weed control is to prevent weed seeds from being brought to the farm, it is important that all possible sources of weeds or weed seeds should be guarded against. The fact that man is the chief agency in the spread of weeds makes it important for each farmer to check on himself in order to avoid the introduction of these pests. The likelihood of crop seeds, such as small grains, alfalfa, clovers, and grass seeds, containing large numbers as well as dangerous weed seeds emphasizes the importance of knowing the quality of seed being sown and keeping in mind that poor seed is costly at any price. Registered or certified seed is the only source of good seed that is available in quantity.

Some of the other important agencies by which weed seeds get to the farms are:

1. Threshing machines, hay, and unground mill feeds are important agencies in carrying weed seeds to the farm, and which many people are likely to overlook.

2. Water, in irrigated sections, is a very effective agency in the spread of weed seeds. Clean ditch banks will do much to lessen the danger from this source; however, a machine has been invented which some maintain will screen out all weed seeds from irrigation water. If this is true, it gives promise of largely solving this problem.

3. Manure, if not properly composted, is often the agency of bringing large numbers of weed seeds to the cultivated land.

4. Wind and birds as well as other animals are other agencies in weed seed dispersal. Birds, however, are far more important as weed seed destroyers than they are as scatterers.

Depending on their life period, weeds are classified into annuals, biennials, and perennials.

Annuals and biennials may be controlled by preventing them from producing seed and perennials are subdued by eliminating any growth above ground. To accomplish this, various methods have been proposed. Some of the most common, in addition to cultivation and crop rotation, are: (1) Treating with some chemical such as common salt, iron sulfate, copper sulfate, sodium arsenite, patent weed killers, carbolic acid, kerosene, crude petroleum, sulfuric acid, caustic soda, corrosive sublimate, carbon bisulfide, and sodium chlorate; (2) smothering either with a crop or with some non-living material, such as straw, leaves, tar paper, etc.; (3) flooding and keeping the weeds covered with water; (4) pasturing; (5) burning; and (6) digging.
Since a farmer's chief business is to grow crops and not weeds, he should strive to produce high acre-yields and at the same time solve his weed problem. To accomplish this, crop rotation and timely cultivations are his most effective methods. At the same time he should take advantage of the important fact that all weeds are killed with the least effort while they are in the seedling stage. The seed-bed should be prepared with the aim of killing the weeds.

To eradicate obnoxious perennials, like morning glory, white-top, perennial sow thistle and Canada thistle, frequent cultivations with an implement which cuts the entire plant has given the most satisfactory results. Small isolated patches of pernicious perennial weeds on cultivated land may be exterminated by the use of chemicals. Carbon bisulfide when used under proper moisture conditions has given good results. On land not used for cropping common salt is also recommended.

Sodium arsenite and patent weed killers, of which one of several arsenic compounds is usually the chief killing constituent, are effective in killing the vegetation above ground and may be used to prevent weeds from seeding. When these materials are used to eradicate perennials repeated sprayings are necessary as long as new shoots appear.

Alfalfa as a smother crop has given good results in crowding out morning glory where conditions were so favorable for the growth of alfalfa as to give a rather quick, heavy stand. However, in most cases the alfalfa has held the weed only in suppression and possibly weakened it some, but after the crop was plowed up the weed soon appeared. Russian sunflowers and corn have been used as a smother crop for pernicious perennials; however, they have been effective in weakening the weeds rather than in eradicating them.

Of the non-living smother material used to control weeds, tar paper or similar material has given fairly good results when properly used. However, because of the expense involved, this method is adapted to small patches only.

Flooding with water will kill pernicious weeds if the soil conditions are such as to maintain a layer of water sufficiently deep to keep the weeds completely submerged.

Pasturing is a very effective and practical method in keeping weeds from producing seeds. It is especially adapted to the control of weeds along the fence lines, ditchbanks and other non-cultivated areas. It is a means of converting these otherwise troublesome plants into a product of money value such as wool or meat, or both. Sheep or goats are the best animals to use in grazing these areas.
Digging to control weeds is adapted only to small areas. However, farmers should be on the constant lookout for new plants that appear on the farm, as usually pernicious weeds appear first in small patches which if taken early may be dug out and destroyed with little effort.

Highways, waste places, and ditchbanks are too often breeding grounds for weeds, many of which ultimately reach the cultivated land. Because of this, those weeds which are likely to give trouble should be controlled; the method used will depend on the conditions. It should be kept in mind, however, that many of these places could be put under cultivation and planted to crops while others are very favorably situated for pasturing; still others will necessarily need to be cleaned up by any one of a number of ways, such as mowing, scything, spraying, salting, saturating with oil, burning, or treating with carbon bisulfide.

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"INSPECTION FOR AND DESTRUCTION OF NOXIOUS WEEDS"*

"An Act to amend Sections 1, 2, and 7, Chapter 124, Session Laws 1919, as amended by Chapter 7, Session Laws 1921 and Sections 3, 4, 5, and 6, Chapter 124, Session Laws 1919, and adding Section 9 to said chapter relating to noxious weeds.

"Be it enacted by the Legislature of the State of Utah:

"Section 1. Sections amended. That Sections 1, 2, and 7, Chapter 124, Session Laws 1919, as amended by Chapter 7, Session Laws 1921, and Sections 3, 4, 5, and 6, Chapter 124, Session Laws 1919, are amended to read as follows:

"Section 2. Noxious Weeds—Destruction—Notice. The State board of agriculture is hereby authorized and empowered to designate and declare by regulation the injurious and noxious weeds to the State and every railroad, canal, ditch and water company and every person, firm and corporation owning, controlling or occupying lands in this State, and every county, municipality, irrigation or drainage district having the supervision and control over streets, alleys, lanes, rights of ways or other lands shall cut or destroy all weeds declared and designated as noxious and injurious to vegetation before such weeds shall propagate or spread and whenever required by the State board of agriculture or the agricultural inspector or deputy.

"Section 3. Enforcement of State board. It shall be the duty of the agricultural inspectors and deputies acting under the direction and supervision of the State board of agriculture, to enforce the provisions of this chapter.

"Section 4. Investigations—Notice—Filing. It shall be the duty of the agricultural inspectors and deputies to make careful examination and investigation in their respective districts, of the spread, development and growth of noxious weeds, and upon discovery of such weeds it shall be the further duty of the said inspectors and deputies to ascertain the names of the owners of the land, and the description of the land where said weeds are found and to serve notice in writing upon the owner, owners, or occupant of said land, either in person or by mailing said notice, postage prepaid addressed to the owner, owners or occupant at the last known post office address as disclosed by the books and records of the county assessor of the county in which the property is located, to cut, eradicate or destroy said weeds within such time as designated by the inspectors or deputy. One notice shall be deemed sufficient on any lot or property for the entire season of weed growth during that year. The inspector shall make proof of service of said notice under oath, and file the same in the office of the county treasurer.

"Section 5. Failure of owner of occupant, procedure. If any owner, owners, or occupant of the lands described in the notice served by the said inspector or deputy shall fail or neglect to cut, destroy or eradicate the weeds, upon the land described in accordance with the requirements of said notice, it shall be the duty of the said inspector or deputy, at the expense of the county in which notice has been served, to employ necessary assistance and to cause such weeds to be removed or destroyed. He shall make, in triplicate, itemized statements of all expenses incurred in the removal and destruction of the weeds and shall deliver the three copies of said statement to the county treasurer within 10 days of the date of the completion of the work of removing the weeds.

"Section 6. Cost to be Taxed—Objection—Hearing—Lien on Land. Upon receipt of the itemized statements of the cost of removing weeds it shall be the duty of the county treasurer forthwith to mail one copy to the owner of the land from which the weeds were removed, together with a statement that objections may be made to the whole or any part of the statement so filed to the board of county commissioners within 30 days. A hearing may be had upon objections made. The county treasurer shall, at the same time, deliver a copy of the statement to the clerk of the board of county commissioners. If objections to any statement are filed with

the county commissioners, they shall set a date for hearing, giving notice thereof and upon the hearing, fix and determine the actual cost of removing the weeds and report their findings to the county treasurer. If no objections to the items of the account so filed are made within 30 days of the date of mailing said itemized statement it shall be the duty of the county treasurer to enter the amount of such statement upon his tax roll in a column prepared for that purpose and likewise within 10 days from the date of the action of the board of county commissioners upon objections filed to enter the amount found by the board of county commissioners as the cost of removing the weeds in the prepared column upon the tax rolls. If current tax notices have been mailed, said taxes may be carried over on the rolls to the year following. After the entry of the costs of removing said weeds by the county treasurer, as hereby provided, the amount so entered shall have the force and effect of a valid judgment of a court of competent jurisdiction, and shall be a lien upon the land from which the weeds were removed and shall be collected by the county treasurer at the time of the collection of the general taxes, and upon payment thereof, receipt shall be acknowledged upon the general tax receipt issued by the treasurer.

"Section 7. Cost Taxed to Municipality. Any expense incurred by the county in the removal of noxious weeds from any property owned or controlled by a municipality shall be repaid to the county from the general fund of the municipality upon receipt of a statement of the expense so incurred, provided that in cities of the first or second class no weed eradication on city streets or other city property at the expense of the municipality shall be undertaken without first giving said municipality an opportunity to clean its own property.

"Section 8. Petition to Declare Weeds Noxious. Whenever 50 or more taxpayers within any county, precinct or municipality petition to make any weed noxious within said county or municipality the State board of agriculture may, after investigation, declare said weeds to be noxious within said county or municipality.

"Section 9. 'Unconstitutional' Reservation. If any section, subsection, sentence, clause or phrase of this Act is for reason held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this Act. The legislature hereby declares that it would have passed this Act, and each section, subsection, sentence, clause or phrase thereof, irrespective of the fact that any one or more sections, subsections, clauses or phrases be declared unconstitutional.

"Approved March 14, 1925."

The following weeds are declared to be noxious in Utah by the Board of Agriculture: Canada thistle, bull thistle, burdock, whitetop, wild morning glory, cocklebur, whorled milkweed, Russian knapweed. (From RULES, LAWS, REGULATIONS AND QUARANTINE ORDERS, State Board of Agriculture, 1926, p. 38).

(College Series No. 247)