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Cultural and Chemical Practices for Commercial Potato Weed Control

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Commercial potato production is not feasible without special operations to control weeds. All potato fields have enough weed seeds that the resultant weeds can destroy the potato crop, for all practical purposes.

Weeds Reduce Productivity

Fields with poor weed control lose 15 percent or more of their potential productivity. Cultivation for weed control is a general practice that in itself results in average losses of more than 5 percent of the crop. Quality is lost too, because of adverse side effects of cultivation. In addition, misuse of herbicides causes losses through injury to potatoes or to crops grown in rotation with potatoes that were treated in the wrong manner with persistent herbicides. Together, uncontrolled weeds and the adverse effects of normal weed control practices are costing Idaho potato growers the equivalent of more than 7 percent of the crop. Better weed control practices will reduce these losses.

Cultivation, Handweeding or Herbicide?

Handweeding is too labor-intensive to plan as a preferred alternative to other methods for large-scale production. For hand pulling, weeds must be allowed to grow so large that they damage the crop through competition. The hand operation damages the crop as well, due to crop disturbance from pulling or hoeing and from compaction due to foot traffic. Hand work shares many of the disadvantages and advantages of cultivation, but is generally considered too costly and unreliable for an economic potato enterprise.

Most farmers use a combination of cultivation and herbicides. For some, however, the question may be "which should I use?" Here's how they compare:

A. Advantages of cultivation over herbicides:

1. Cultivation is the most economic alternative to handpulling where herbicides are not used, such as in organic farming or on large tracts.
2. Cultivation uses equipment investment more fully.
3. Cultivation is effective on all annual species when they are small (4 true leaves or smaller).
4. Cultivation is partially effective on perennial weeds.
5. Cultivation requires less technical competence.
6. Cultivation poses fewer technical hazards.
   a. Operation is not restricted by windy weather or adjacent, herbicide-sensitive crops.
   b. No chemical residues can get into the potato crop or remain to threaten next year's crop.
   c. Fewer government requirements restrict cultivation.

B. Disadvantages of cultivation compared to herbicides:

1. Cultivation is not effective on wet soil (after irrigation or rain).
2. Cultivation is slower, requires repeated operations, resulting in more labor costs and exposure to risk of accidents.
3. More crop damage results from cultivation than from spraying.
   a. When a 4-row cultivator is used, every row is adjacent to and affected by compaction from tractor wheels. This causes clods, which bruise potatoes at harvest, and reduces soil aeration, which reduces potato growth. One-fourth of the field is covered with wheel tracks from that operation. Two-thirds of the rows are adjacent to and affected by wheels of a 6-row cultivator. Sprayer swaths are two to five times as wide with proportionally less compaction.
   b. Potatoes require continuous high soil moisture, resulting in easily compacted soil.
   c. Cultivators can damage crop roots and tops, which reduces yield and decreases the percentage of No. 1's.
   d. University of Idaho tests show that growers who followed normal cultivation practices (two cultivations) lost between 12 and 20 percent of to-

tal yield potential in side-by-side comparisons with good herbicides. Since irrigation practices that provide the best potato growth result in 65 percent or more available soil moisture, the soil is always susceptible to compaction and poor aeration. Losses from cultivation must be balanced with the costs and/or losses from using alternative practices, or of not controlling the weeds.

4. Control within the row is generally not as good as between rows, because covering hilltop weeds does not control them as effectively as cutting or uprooting them in the furrows.
5. Cultivation cannot control weeds that germinate after lay-by.
6. Continual tillage promotes water erosion on sloping soil.
7. Some mosaic diseases (such as PVX, PVS and to a lesser extent, PVY) are transmitted by cultivators brushing by foliage of emerged potatoes at lay-by. This is especially undesirable to seed producers.

The comparative cost of control depends on the procedures used, the equipment used and the number of operations performed. Table 1 compares costs of two types of herbicide programs and one type of cultivation program. Although the total costs are different, choice should be based on the above list and the procedure's ability to solve the weed problem in a particular field and the probable return on investment, rather than cost alone.

Don't do a partial job of weed control. Here are some management principles and weed control practices for a sustainable agriculture system that should be followed for any well-planned weed control program:

1. There are many weed species you don't have yet. Don't get them. Follow these practices:
   a. Use clean, tested, tagged seed when planting other crops in the rotation. Certification is an important protection, but it's not a guarantee against serious new weed species that can increase in your fields. Inspect seed yourself before buying, and at **least** check the tag. All seed sold through commercial channels must by law be labelled.
   b. Don't let dirty vehicles, equipment or livestock on your place. Mud almost always contains weed seeds and should be washed off.
   c. Keep weeds out of adjacent waste areas, fence rows, roadsides, field borders and ditch banks. Most weeds spread from these areas. Don't rely on soil sterilants to control weeds there. Instead, plant a good grass for biological control, then keep it weed-free and healthy.
   d. Screen seeds from irrigation water at headgates and pumps.
   e. If you see unknown or new weed species, take extra precautions by removing and burning them, but get them identified before destroying them.
   f. Don't give up because you know some seeds survive in the soil for many years. Only a fraction of the total seeds do survive, so it always helps to keep the numbers down. Even in long-lived species, most of the seeds will germinate or die in the first 2 to 5 years.
2. Control weeds in previous crops so fewer seeds enter the soil in your field.
3. Irrigate in the late summer or early fall after the previous crop has been harvested to encourage germination of weeds. This allows control by late fall or spring spraying, tillage and winter freezing.
4. Grow a vigorous, healthy potato crop. The best weed control weapons you can have are vigorous, competitive potato plants that emerge early, close the rows rapidly and remain healthy until vine kill in September. Optimum seed size and quality, adequate soil fertility for good potato nutrition, well-scheduled irrigation, disease control, good soil physical condition and insect control will enhance the vigor and health of your potatoes.

Table 1. Comparative costs of selected weed control practices.

Operation or item	Herbicide program: Surface applied	Herbicide program: Mechanically incorporated	Cultivation program
	(---------- dollars per acre ----------)		
Drag-off (may be used in conjunction with herbicide program)	-	-	$ 4
Hilling once (cultivator with tractor)	$ 11	$11	-
Cultivation 3 to 4 times (cultivator and tractor)	-	-	33-44
Sprayer with tractor	3	-	-
Herbicide one application	6-22	16	-
Disk-mounted sprayer with tractor	-	10	-
Disk incorporation with tractor	-	8	-
Totals	$24-27	$45	$39-48

Cultivating for Potato Weed Control

Best cultivation practices depend on several factors that must be considered in planning any kind of weed control program, and occur in many combinations:

1. Annual weed species in the field,
2. Perennial species in the field,
3. Soil characteristics,
4. Time of emergence of various weed species in relation to time of crop emergence. This is determined by:
   a. weed species,
   b. planting date,
   c. tillage practices,
   d. soil temperature,
   e. drying conditions,
   f. seed bank (amount of seed) in the field,

g. prior germinating conditions,
h. planting equipment,
i. field surface configuration after planting and
j. weather.

5. Kind of tillage equipment available,
6. Soil moisture and irrigation schedule,
7. Kind of irrigation system,
8. Hilling practices,
9. Row width and
10. Crop purpose (seed vs. commercial).

Principles of Successful Cultivation

The way the following principles are applied depends on individual cultural practices such as whether a herbicide is to be used in combination with cultivation.

1. Use hilling operations for weed control. Leave the field flat after planting; begin to hill up only after weeds have emerged; hilling also cultivates (thus serving as one cultivation operation) and allows maximum opportunity to cover weeds in the row.
2. Kill the weeds when they are small. Cultivate before broadleaf weeds get past the 2-true-leaf stage (2 cotyledons plus 2 true leaves). If allowed to grow larger they can re-root, and those on the hills can re-emerge through soil thrown up to cover them. One University of Idaho study demonstrated that the longer annual weeds were allowed to compete with potato plants, the greater the yield loss. When weeds were allowed to compete for 60 days after potato emergence, the yield reduction was 48 percent. When competition was limited to 15 days, the yield reduction was only 2½ percent.
3. Avoid potato sprout injury. If weeds reach the 2-true-leaf stage before the potato sprouts are within 2 inches of the soil surface, "drag off" the weeds with a flex-tine or spike-tooth harrow. Check to ensure that all weeds are being uprooted; if not, add a second gang of harrows behind the first. Pulling a ripper shank behind the tractor wheels while harrowing will reduce compaction and help guide the tractor more precisely for the next operation, which should not be needed until the potatoes are well emerged.
4. Don't cover potato plants completely. The first cultivation after potatoes emerge should be done with equipment adjusted to throw soil around the base of the potato plant, covering small weeds without covering more potato leaves than necessary. If weeds are in the 2-true-leaf stage before the potatoes are large enough to avoid covering, it is advisable to "blind cultivate" again, but using a flex-tine harrow. Potatoes that have just emerged are normally vigorous enough to survive a flex-tine harrowing with no more than about 5 percent shoot breakage. Plants with broken shoots will be set back as much as they would be from a freeze, but this loss must be considered as one of the costs of weed control. A small amount of shoot breakage is preferable to covering all the potato plants with a hilling operation.
5. Plan the hill-building process. In all cultivations except the last one, throw enough soil with the cultivator to cover the entire hill with 1 to 2 inches of soil to kill those weeds within the row that the cultivators cannot uproot. Less soil than this will not cover uniformly to kill all weeds throughout the field; more soil will build the hill too high or too soon so that late cultivation cannot add enough soil to the hill to cover and kill young weeds.
6. Cultivate on the driest part of the field, and allow weeds to die by drying before irrigating. Do not allow the soil to fall below 65 percent available soil moisture in the upper 6 inches, because this will stress the crop excessively. If you have a center pivot irrigation system, cultivate one half at a time, starting at the middle of the circle. Schedule the irrigations to allow at least 1 full day of drying after cultivation and before the next forecast rainfall or the next start of irrigation. Cultivate **at least** 1 day ahead of the next forecast rainfall or scheduled irrigation set if you use furrow, wheel lines, hand lines or solid set irrigation systems.

   Cultivate **only** the second-to-next set to be irrigated (normally one day before next irrigation), if consumptive use requires continual irrigation at the time cultivation is necessary. This is for three reasons: (1) cultivated weeds die most readily in the driest soil, (2) at least 1 day of lying uprooted in dry soil will kill most weeds in the 2-true-leaf stage or smaller, and (3) less soil compaction occurs on the dryer soil, thus minimizing not only yield reduction caused by compaction but also clod formation, which is an important factor in harvest bruise prevention.
7. Synchronize the last cultivation with the closing of the potato rows. The last cultivation must form the final hill by throwing enough soil on the hill around the base of the potato plants to kill the small weeds on the hill. This operation, called the "lay-by" cultivation, should be performed well before the "rows close," i.e. before the leaves from adjacent hills touch each other above the furrow.

   Where potatoes grow well enough to close the rows at midseason (mid-July), lay-by cultivation should be done when the plants are still 12 inches apart. At this time, an 18-inch tire can pass without significant crop damage, and root pruning will be minimized. These factors are important because midseason stress can cause premature decline of the crop, tuber malformation and other crop quality loss. The rows will grow too close to avoid damage within 5 days.

   After a week to 10 days, the rows will be completely closed, and a vigorous crop canopy will prevent most weed development. Some weed seeds may germinate and emerge, but the weeds will be suppressed with few exceptions. Among the exceptions are perennials like Canada thistle or shade-tolerant annuals like nightshade. Nightshade will survive but will not be released

from competition until vines begin to die from frost or late season disease.

8. Promote full-season potato growth for full-season weed control. Manage for control of end-of-season weeds by maintaining crop growth with adequate soil moisture, adequate nitrogen levels and other disease suppression measures to retard Verticillium wilt, early blight, leaf roll virus and other diseases.
9. Kill late-season weeds before they seed, along with potato vines, with effective vine-killing procedures. This may be done by either chemical or mechanical procedures.

Common Errors in Potato Cultivation

1. Trying to realign hills with planted rows of potatoes. If the hills are crooked due to misaligned planter hilling or bad cultivation, leave them that way. Attempts to straighten the rows only make alignment worse, usually result in the inability to cultivate effectively and cause more potato plant injury and green ends.
2. Cultivating too deep. Cultivate only deep enough to kill weeds. Deeper cultivation uses more fuel, disturbs crop roots and slows the operation.
3. Cultivating soil that is too wet. Weeds will readily reroot, and soil compaction can be serious.
4. Failing to cultivate after a late spring or early summer frost or hail reopens the vines after lay-by. If the vines are frozen back severely, frost-tolerant weeds will be released from potato competition and will develop into a severe problem, so an extra cultivation or herbicide may be needed.
5. Failing to monitor cultivator operation. Rolling cultivator gangs may fill up with vegetation or soil and lose effectiveness or even stop rolling and start pushing soil. Shovels may shift due to loose bolts, and loose hookups may affect tracking.
6. Failing to cultivate matched sets of rows. A cultivator should never cover more than one planter width or straddle "guess rows" (rows belonging to adjacent planter passes). Planter accuracy is not adequate to maintain constant, precise "guess row" spacing. Potato injury and uneven weed control may result.
7. Failing to follow planter marks as cultivator tractor guides. A tractor driver's estimate is seldom adequate for precise cultivator guidance. Driving in ripper marks is better. Single-rib tractor tires help.
8. Covering potato plants. The delay in growth will be at least proportionate to the number of days the plants have been emerged. Research shows that each day's delay during a normal spring can cost 5 cwt per acre.
9. Failing to irrigate as soon as weeds are dead. Adequate weed kill generally requires 1 full day of lying in hot, dry surface soil. If irrigation is delayed too long, the crop can be excessively stressed.

What Kind of Cultivator Is Best?

There are no authoritative answers. Each kind is used in a different manner. Rolling cultivators are excellent for early and mid-season cultivation but are not generally favored for a late lay-by cultivation because the gangs catch the potato leaves and stems. Shovels are better for this purpose. Shovels must be adjusted properly or they will injure plants and form an improper hill. Light duckfeet or sweeps do not kill weeds well on the sides of hills but are adequate in the furrow bottom.

How To Use Herbicides For Potato Weed Control

1. Diagnose the weed problem.
   a. Find out what weeds are in your field. Herbicides are selective and, like medicines, are not cure-alls. They must be chosen to fit both the problem (the weed) and the "patient" (the field).
   b. Find out whether your weeds are susceptible to registered potato herbicides. Learn if the weeds are seed-dependent annuals or more resistant perennials. Plan to handle resistant perennial weeds as a separate problem.
2. Plan the treatment well in advance to avoid possible complications.
   a. Choose a herbicide or combination of herbicides that, combined with cultivations and other practices, will control all important weed species in your field. A surviving major species can cause as much competition as if the other species had not been controlled.
   b. Determine exactly how and when the herbicide is to be applied. Plan every detail of herbicide management into the cultural program. Review the label thoroughly. Choose an effective rate, but do not exceed the labelled dosage for your conditions because that could cause excessive residues in the potatoes, injury to the potato crop or injury to the next crop in rotation.
   c. Plan to kill weeds before they grow beyond the seedling stage (2 true leaves). It takes less herbicide and is more effective.
   d. Determine how use of the herbicide will affect other cultural operations and anticipate necessary changes in the usual procedures.
   e. Anticipate changes in kinds, adjustments in or use of equipment that may be required to use the herbicide, and learn any necessary special techniques and skills.
   f. Determine if additional herbicide treatments will be necessary.
   g. Find out if other crops you expect to use in the rotation after potatoes will be affected by herbicide use in the potato crop. Learn whether special efforts such as deep plowing will be needed to protect the next crop from traces of undecomposed herbicides, or whether you must select a different crop after potatoes.

h. Find out from the label directions whether you can cultivate or operate equipment in the field after treatment without jeopardizing weed control.

i. Make final hill or other necessary surface conditioning to prepare for the herbicide application.

j. Plan for proper soil moisture conditions to ensure herbicide effectiveness. For some herbicides, you must be prepared to irrigate immediately after spraying.

3. Check out all application equipment. Fill the tank with plain water for this.

   a. Check sprayer for proper operation: pump, screens, agitation system, connections and fittings, pressure regulator, gauges and nozzle tips. Inspect each tip to ensure that all are the same size. Replace tips and rubber or neoprene components where needed. Be sure that the nozzle spacing on the boom is correct, and that the correct boom height will be maintained throughout the job.

   b. Calibrate sprayer. Calibrate **each tip** individually. Each tip should deliver within 10 percent of the rated average specified in the manufacturer's manual. Use the amount of water per acre that the label specifies. If it doesn't specify, you are safe to use 10 to 20 gallons per acre at 20 to 40 psi for adequate coverage of soil surface if a surface-applied herbicide is to be used. Check your tractor speedometer/tachometer for accuracy under field soil conditions. Don't assume it is correct.

   c. Adjust and lubricate incorporation implements. If preparing to spray a soil-incorporated herbicide after planting and before potatoes emerge, ensure that the incorporation implement teeth will mix the upper 2 to 4 inches of a pre-bedded potato hill on the proper row spacing.

   d. Field test the entire mechanical assembly. Be sure that the entire tractor-drawn setup will be able to maintain a precise, constant speed in the field to deliver the right amount of spray. This is especially important for fields with slope. Changing gears or rpms causes serious variations in rate.

   e. Check your calculations!

When You Use Herbicides

Verify whether the herbicide you intend to use is registered for use in potatoes by the EPA or the Idaho Department of Agriculture (if so, the label will list potatoes), and check to see whether new options have become available. Registrations may change at any time, so be sure you have an up-to-date label. Herbicides listed in University of Idaho publications are approved for use at the time of publication, but changes are expected to occur each year.

Read and understand the directions on the container label, then **follow them strictly**. Be sure to devote special attention to sections of the directions given especially for potatoes. If you have not had adequate experience with the proposed herbicide or method of use, obtain information from licensed, qualified specialists for guidance, in addition to the container directions.

Applying Herbicides

Use any equipment that can uniformly, accurately and completely deliver the herbicide according to label directions. The basic methods are by (1) ground-operated boom sprayer, (2) aircraft and (3) irrigation system. The suitability of any method depends on the care with which it is used. Each system has its unique advantages over other methods as well as inherent drawbacks.

Aircraft — The advantages of aircraft are the speed with which a field may be treated, the avoidance of soil compaction or mechanical injury to the crop and the ready availability of custom aerial applicators. Speed of treatment is often important for a timely application of a herbicide, and custom services can provide relief during a busy farming schedule. On the other hand, off-target drift can occur more readily from aircraft because of greater equipment height, vortex and other aerodynamic factors such as windy conditions or low-level inversions. Aerial swath spacings and swath boundaries are less precise than for ground equipment.

Ground Sprayers — Ground-operated boom equipment can be the most precise with the least off-target drift. Its use, however, is limited by slowness of job completion, by soil physical conditions such as moisture in irrigated parts of the field and by windy conditions. It results in more mechanical crop injury if the crop is near a lay-by condition.

Irrigation — The advantages of using irrigation for the herbicide distribution system include:

1. Soil compaction and crop injury are not aggravated because no additional field equipment is used.
2. Uniformity of application is excellent in properly designed and maintained systems.
3. The associated large volume of water is an effective mechanism to leach the herbicide into the soil.
4. In the case of sprinkler irrigation, the rinsing effect of the large volume of water reduces the amount of herbicide retained on the crop leaves.
5. There is less pattern displacement by light winds because of the repeated sprinkling.

Windy days are especially severe deterrents to spraying in years when springtime winds continue from daybreak until dark for several weeks during the time that spraying is needed. Since irrigation equipment does not depend on human guidance, it can apply the herbicide during the calmer, nighttime hours. In the case of surface irrigation, wind is of no consequence.

Continuously moving, linear or center pivot systems apply herbicide more uniformly than fixed-set systems such as wheel-move, hand lines or solid set. They can cover a field in less time and are less subject to leaks or failures due to frequent disconnection, disassembly, reconnection and restarting.

Fixed-set systems, however, allow more control over the way in which the herbicide is leached into the soil, and therefore can use some herbicides more efficiently. For example, studies show that some herbicides applied during the last portion of an irrigation set may be lost from the soil surface or may be ineffective while a herbicide applied earlier in the irrigation set is moved deeper into the zone of germinating weed seeds. As it happens, the volumes of water used for sprinkler irrigation of potatoes (generally ½ inch to 2 inches) coincide with the most effective amounts of water needed to leach in the herbicides registered for that use on potatoes.

Drawbacks to or inconveniences of herbicide application through irrigation systems are:

1. Only a few herbicides are registered for application through sprinklers. These are soil-applied herbicides because the large volumes of irrigation water move most of the herbicide through the foliage to the soil.
2. Irrigation may not be appropriate when the herbicide is needed, due to spring rains, need for early season application, irrigation scheduling, etc.
3. Some short-distance, off-target drift can occur from sprinklers during air inversion conditions or light winds. Also, sprinklers often place some water well outside the field boundaries.
4. Strict state and federal requirements specify fail-safe devices and procedures to prevent back-siphoning of pesticides into wells or points where water supplies could be contaminated.

The most suitable methods of application must be selected according to conditions prevailing in each situation, taking into account many aspects of a potato production enterprise.

Perennial Weed Problems

Perennial weeds will reduce yields more than annual weeds because perennials are not controlled as well as the annuals in potato crops. Canada thistle has reduced potato yield as much as 70 percent, field bindweed 16 percent and Russian knapweed 32 percent. Quackgrass will cause not only serious yield loss but also quality reduction from tuber deformation and penetration of rhizomes into tubers.

Growing potatoes in fields heavily infested with deep-rooted perennial weeds is not recommended. Control programs have been developed, however, to help a grower fight perennials when potatoes are not being grown in the infested field.

Serious perennial weed problems must be solved with persistent programs for several years. See your county agricultural Extension office or other qualified production advisor for recent publications and other information on perennial weed control in certain crop situations.

For additional information on potato production, contact the University of Idaho agricultural agent in the Cooperative Extension Service office in your county seat.

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