Crop Profile for Potatoes in Idaho

Prepared June, 2000

General Production Information

- Ranks first in U.S. production of potatoes
- Produces 29% of the total U.S. crop
- Produces 137 million cwt.
- Crop value is $670,000,000 (average 1995-1997)
- Production cost per acre is $1,507.00
- Storage costs add approximately $290.00 per acre
- Production costs vary across the three major growing regions
- Production and processing account for over 15% of all Idaho income
- Idaho potato production is as follows:
    - Processed - 64%
    - Fresh tablestock - 30%
    - Seed potatoes - 5%
    - Chip - 1%
- Organic potatoes are produced on 814 acres.

Idaho is the nation's leading potato producer and its annual potato harvest is one of the state's leading outside income sources. The economic effect of potato production, in Idaho, is magnified by the many links in the production chain. Most of the seed potatoes planted by Idaho potato producers are grown in eastern Idaho. Most all of the potato planters and harvesters are manufactured in Idaho, and there are the "value added" products produced in the state such as dehydrated and frozen potato products and the fresh shippers.

Production Regions

Major production regions are adjacent to the Snake River Plain of southern Idaho, where water is available for irrigation.

- **Southwest**- 7% of the potato acreage - 8% of production. Counties include: Ada, Canyon, Elmore, Owyhee, Payette, Valley. Southwestern Idaho grows potatoes for the frozen potato processing market.
- **Southcentral** - 28% of the potato acreage - 32% of production. Counties include: Blaine, Cassia, Gooding, Jerome, Lincoln, Minidoka, Twin Falls. Southcentral Idaho, also known as the Magic

Valley, produces potatoes for both fresh and processed markets.

- **East** - 65% of the potato acreage - 59% of production. Counties include: Bannock, Bingham, Bonneville, Butte, Caribou, Clark, Custer, Fremont, Jefferson, Madison, Power, Teton. Eastern Idaho is where much of the state's fresh potatoes are grown. Dehydrated potato processors are also found in eastern Idaho. Most of the state's seed potatoes are produced in this region.
- **North** – 1% of the potato acreage – 1% of production.

Cropping Practices:
Soils are volcanic derived and range in texture from sandy to clay loam. The soil types are favorable for potato production. The arid climate is characterized by hot days and cool nights, and promotes excellent potato growth.

Planting begins April 1 in the Southwest and ends June 10 in the East. Cultivation is used for weed control, aeration, and proper seed depth to prevent greening of the tubers. Sprinkler irrigation is used on 99% of crop and furrow or rill irrigation is used on 1%. Irrigation allows for precise management and application of water, nutrients, and crop enhancement materials. Harvest begins after tuber maturity, usually beginning July 15 and continuing through November 15, moving from the southwestern part of the state to the east. Harvested potatoes are then placed in storage for future processing or fresh market use.

Integrated Pest Management Practices:
All growers practice some elements of integrated pest management (IPM). Field scouting and testing, crop rotation, planting disease free clean seed, pest forecasting and determining economic thresholds preclude pesticide application. Based on a statewide survey, adoption rates of IPM sampling and decision-aids have increased moderately since 1992.

The following are some of the IPM practices used by growers:

- 83% of growers use economic thresholds to determine pesticide application.
- 72% of growers rotate insecticides to avoid the buildup of resistance.
- 43% of growers practice cultural controls to reduce insect populations.
- 33% of growers scout fields for natural enemies.
- 24% of growers reduce insecticide use to protect beneficial insects.

The use of certified seed and planting resistant or tolerant varieties are common IPM practices. In addition, potatoes are rotated with other crops such as small grains, legumes, and green manure crops to suppress the development and movement of soilborne diseases, weeds, insect, and nematode pests.

Insect Pests

The most serious insect pests are green peach aphid, Colorado potato beetle, and wireworms.

Green Peach Aphid (GPA)

Myzus persicae

Green Peach Aphid (GPA) is one of the most serious pests in Idaho potato production. A survey of Idaho potato growers showed that the GPA is considered a "serious pest" by 37% of the growers. It causes economic loss every year, mainly because of the transmission of potato leaf roll virus. Leaf roll is one of most serious diseases of potatoes. Aphids overwinter as eggs in peach trees and spread to potato fields, laying live young that live on the underside of potato leaves. Aphids can mechanically spread leaf roll virus to healthy plants. Damage involves stunting of the plant and serious internal browning of the tubers. Yield and quality are significantly reduced. Estimated crop loss without control ranges between 40% - 70%.

Since only a small percentage of internal disorders such as net necrosis can be tolerated and aphid flights can be heavy, very few, if any, GPA can be tolerated by potato producers, especially by seed producers. Essentially all aphids must be prevented from surviving on commercial and seed potatoes.

The action threshold in south central Idaho for aphid control is reached when population density of wingless green peach aphids exceeds 10 aphids per 50 potato leaves for 2 consecutive weeks. In southwestern Idaho, the corresponding threshold is 40 aphids per 50 leaves.

Control:

Chemical Control:
Growers will use an insecticide at planting or a foliar treatment following cultivation. Eighty eight percent of the growers scout for aphids to determine the action threshold before applying foliar insecticides.

Many insecticides registered on potatoes do not give satisfactory aphid control. The Green Peach Aphid (GPA) is one of the few insect species reported to be resistant to compounds of all classes of

insecticides: organochlorines, organophosphates, carbamates, and synthetic pyrethroids.

The GPA has shown resistance to the synthetic pyrethroids, esfenvalerate and permethrin. Pyrethroids are generally not effective against aphids, but are used extensively on potatoes because they have a broad-spectrum of activity against other pests and are cost-competitive. Soil-applied insecticides give good control of early season aphids. Even with effective residues, many aphids escape and infect other plants with the potato leaf roll virus (PLRV). It is important to maintain full season aphid control to reduce the possibility of PLRV. Reducing aphid populations to tolerable levels requires a combination of control measures using cultural practices and several insecticides with different modes of action.

Phorate (Thimet) – Most widely used soil applied insecticide. Applied to 41% of the acres for CPB, leafhopper and wireworm control but it may give fair control for early season aphids. Phorate is a systemic insecticide applied at planting. Average rate is 2.64 pounds active ingredient per acre, with one application per year.

Methamidophos (Monitor) - This is an extremely potent insecticide that provides contact and systemic activity. It provides 10 to 14 days control in late season and is used on 30% of the acres. Methamidophos should be applied just before the break in efficacy of the soil applied insecticides, in order to maintain full season aphid control. This is crucial to prevent the infestation of PLRV. Methamidophos is applied an average of 1.3 times per season at the average rate of 0.95 pounds active ingredient per acre.

Aldicarb (Temik) – This soil insecticide is applied at planting on 11% of the acres. It is applied at the average rate of 2.62 pounds active ingredient per acre, with one application per year. Aldicarb also controls Colorado potato beetle and nematodes.

Endosulfan (Thiodan, Phaser) - Contact and systemic insecticide applied to 13% of the acres. Endosulfan provides fair control of green peach aphid. The average rate used is 0.86 pounds active ingredient per acre and 1.7 applications per year. Endosulfan is less effective than methamidophos, for GPA control. This lack of effectiveness from endosulfan can cause up to a 10% yield loss due to more aphid damage and virus spread.

Disulfoton (Di-Syston) – This insecticide is used on 4% of the acres for aphid control. It is applied at an average rate of 3.06 pounds active ingredient per acre one time per year.

Alternative Insecticides:

Imidacloprid (Admire) – A soil applied insecticide that offers good control of GPA. An effective alternative insecticide to methamidophos. Imidacloprid also controls Colorado potato beetle, but it does have a higher cost to the producer. This insecticide is applied to 8 % of the acres one time per year at the average rate of 0.20 pounds active ingredient per acre.

Integrated Pest Management and Cultural Control:
Cultural control methods are an integral part of reducing populations of GPA. *Prunus* and other host species are treated with insecticides or eradicated to control aphids. These treatments will limit the overwintering capacity of the aphids and reduce infestation in potato fields. Growers use resistant varieties and certified seed free of PLRV. Eighty eight percent of the growers examine potato leaves for aphids.

Colorado Potato Beetle (CPB)

Leptinotarsa decemlineata

The Colorado potato beetle (CPB) is second in importance only to the GPA. The CPB invades potato fields as an adult and will lay 300 to 500 eggs over a 4 week period on the undersides of leaves at scattered locations throughout the fields. The eggs hatch in 4 to 9 days and the larvae feed heavily on terminal growth. Both adult beetles and larvae feed on potato leaves and stems, but the larvae are more damaging. If the larvae are not controlled, they will cause 70%-100% defoliation, ultimately death of the plant, and 40% yield loss. The adult beetles cause some damage but seldom require control.

Control of CPB is primarily with soil applied insecticides. Natural enemies are not sufficiently abundant to contain populations. While synthetic insecticides remain the most effective means for its control, resistance by the CPB to all classes of insecticides has been documented in many U.S. potato-producing regions. CPB resistance was first discovered in Idaho in the mid-1980's. Widespread and locally diverse esfenvalerate and phosmet resistance was detected in all counties in southern and eastern Idaho in 1992. No resistance was detected to carbofuran or endosulfan. Resistance has the greatest potential to eliminate insecticides as useful tools in CPB management.

Control:

Chemical Control:

Phorate (Thimet) – This is the most widely used systemic insecticide to control CPB. It is applied at planting on 41% of the potato acreage. Average rate is 2.64 pounds active ingredient per acre with one application per year. Phorate can be effective on wireworms and early season aphids, although the control is variable.

Endosulfan (Thiodan, Phaser) - This contact and systemic insecticide is applied to 13% of the acres at an average rate of 0.86 pounds active ingredient per acre and 1.7 applications per year.

Carbofuran (Furadan 4F) – This insecticide is applied to 17% of the potato acres one time per year at an average rate 1 pound active ingredient per acre. It is applied as a foliar application from emergence up to the 4-leaf rosette stage. Carbofuran also controls wireworms and aphids.

Aldicarb (Temik) – This soil insecticide is applied at planting on 11% of the acres. It is applied at the average rate of 2.62 pounds active ingredient per acre, with one application per year. Aldicarb also controls green peach aphid and nematodes.

Carbaryl (Sevin) – This is a foliar insecticide applied to 7% of the acreage. Carbaryl is applied at the rate of 0.98 pounds active ingredient per acre, one time per year.

Alternative Insecticides:

Imadacloprid (Admire) – A soil applied insecticide that offers good control of CPB. An effective alternative to phorate, but it does have a higher cost to the producer. It is also effective against green peach aphid. Imadacloprid is applied to 8% of the acres one time per year at the average rate of 0.20 pounds active ingredient per acre.

Spinosad (Success) – This is a new insecticide that has recently been registered for use. Spinosad is proven effective providing four weeks CPB control and it is safe to beneficials. Spinosad is applied at 3-6 ounces per acre. Very few acres are treated at this time, but the acres treated with spinosad are expected to increase.

Permethrin (Asana) – This insecticide is used on 4% of the acres for CPB control. Permethrin in applied at 0.06 pounds active ingredient per acre one time per year. It will cause aphids to flare.

Biological Insecticides:
Bacillus thuringiensis spp. tenebrionis (Novodor) – This species of Bt has been proven effective, but it is not used for conventional CPB control. It is used by the organic potato producers.

Integrated Pest Management and Cultural Control:
Ninety one percent of Idaho growers scout fields for CPB. The University of Idaho integrated pest management program has developed economic thresholds for CPB dependent upon crop value and insect control costs.

Alternative Control Practices:
There has been an increase in the use of transgenic potato varieties as one alternative control practice. In Idaho, 3.8% of the potato acreage in 1999 was planted to genetically modified (GM) potatoes. Most of these potatoes were planted as an alternative for CPB control. A very small percentage of the GM potatoes (less than 1%) were planted to control leaf roll virus and potato virus y.

Wireworm

Limonius californicus, L. canus, Ctenicera pruinina

This pest is considered serious by 16% of growers, and a moderate pest by 64%. Larvae feed upon potato seed pieces and underground stems during the spring. The early feeding opens the seed pieces and stems to rotting organisms (fungi and bacteria) which result in poor or weak stands. Wireworms also burrow into developing tubers, lowering quality and value of the tuber.

Detecting wireworm infestations and determining populations can be difficult. Baiting gives a poor estimate of population sizes, but is a quick method to determine the presence of wireworms. Soil assay procedures are available to estimate the number of wireworms per square foot.

Control:

Chemical Control:
Use of soil applied insecticides is the main method of control for wireworms.

> **Phorate (Thimet) –** This is a systemic insecticide applied at planting. It is used for aphid and CPB control, but also controls wireworms and nematodes. Phorate is applied to 41% of the acres at an average rate of 3 pounds per acre.
>
> **Ethoprop (Mocap) –** This is a contact insecticide for wireworm control. It is applied to 5% of the acres at 4.49 pounds active ingredient per acre. Ethoprop is applied one time per year.

Alternative Insecticides:

> **Imidacloprid (Admire) –** This is a soil applied insecticide that offers good control of wireworms. An effective alternative, but has a higher cost and more narrow pest control spectrum. Control in Idaho is better than other parts of the United States. Very few acres are treated with imidacloprid. Average rate is 13.1 to 18.9 fluid ounces per acre.

Diseases

There are a number of disease problems in the field and in storage situations. The important diseases occurring in the field are seed piece decay, early blight, late blight, early dying and potato leaf roll virus (PLRV). The diseases that occur in storage are pink rot, pythium leak, late blight, fusarium dry rot and early blight. Silver scurf and bacterial soft rot will follow these diseases infecting the tubers. Early blight and fusarium dry rot infect wounds that are caused from harvest. Seed potatoes have all of the above diseases with potato leaf roll virus being the most serious. Net necrosis of the potato tuber is the result of

infection by potato leaf roll virus. The University of Idaho has published the *Potato Net Necrosis Idaho Action Plan 2000*, which assists producers manage this virus. Seed potatoes also have potato virus y (PVY). Late blight has become more serious is Idaho. The disease has been managed in Idaho, but remains a threat to growers because of new strains, and the unknown severity the disease may have. Late blight is rated by Idaho potato growers as the most serious pest problem.

Late Blight

Late blight is the most damaging later in the growing season. The fungus attacks stems, leaves, and tubers. If wet or damp weather continues after infection, the entire plant quickly decays. At first, the attack appears insignificant only affecting a stem or leaf in small areas of the field. However, the disease can spread so rapidly that in a few days an apparently healthy field may be severely damaged. Approximately 75% of potato acreage receive four or more fungicide applications each year at 7 to 10 day treatment intervals.

Control:

Chemical Control:
There are two types of chemical control used for late blight; protectant and systemic fungicides. Protectants are applied every seven days starting at six inches of shoot growth. Systemics are generally tank mixed with a protectant to avoid resistance. Systemics are applied after the disease has been identified.

Chlorothalonil (Bravo) - 41% of the potato growers use chlorothalonil for control of late blight. It is a protectant fungicide applied on 50 – 60% of the acres, 1 to 5 applications per year. The average rate is 1.25 pounds active ingredient per acre

Maneb - A protectant fungicide applied on 16% of the acres, 1.4 applications per year at 1.05 pounds active ingredient per acre.

Mancozeb (Manzate, Dithane) – A protectant fungicide used on 79% of the acres. Mancozeb is applied an average of 2.6 times per year at an average rate of 1.18 pounds active ingredient per acre.

Cymoxanil (Curzate) – A systemic fungicide applied after late blight has been identified. First used under a Section 18 Emergency Exemption in 1996. Applied on 39% of the acres at the average rate of 0.12 pounds active ingredient per acre. It is applied an average of 1.7 times per year.

Dimethomorph (Acrobat) – A systemic fungicide, first used in 1996 with the Section 18

Emergency Exemption. Dimethomorph is applied on 3% of the acres at an average rate of 0.19 pounds active ingredient per acre 1.3 times per year.

Promamocarb hydrochloride (Tattoo) – A systemic fungicide premixed with chlorothanlonil. This fungicide is only used under the Section 18 Emergency Exemption status of FIFRA. It is applied on 7% of the acres, average rate of 0.90 pounds active ingredient per acre, one application per year.

Disease prediction models based on weather data are used in some areas. These models predict disease occurrence based on temperature and rainfall and/or humidity. They may be used to schedule foliar fungicide applications.

Cultural Control:
The University of Idaho has published the *Idaho Action Plan for Late Blight* which deals with preventative measures that can be taken by producers to avoid late blight infestations. The University also has a Late Blight Hotline, 800-791-7195, for the most up-to-date information on late blight.

Other Diseases

Chemical Control:

Mancozeb (Manzate, Dithane) - In addition to the use of mancozeb as a protectant fungicide for late blight control, it is used both as a foliar and seed treatment for seed fungal problems. It is applied to 25 – 50% of acres just to control early blight, fusarium, and silver scurf. (79% use is the total mancozeb acreage treated, which includes late blight control and those diseases mentioned here). It is applied an average of 1 to 2 times per year at the average rate of 1.18 pounds active ingredient per acre.

Metalaxyl (Ridomil) – This is used to prevent storage rots caused by Fusarium and Pythium fungi. Metalaxyl is applied to 21% of the acres. The average rate used is 0.19 pounds active ingredient per acre 1.3 applications per year.

Thiobendazole (TBZ) – This fungicide is applied to 10 - 20% of acres. Thiobendazole controls Fusarium Rots, Rhizoctonia, stem canker, black scurf and silver scurf. It is applied at the average rate of 0.11 pounds active ingredient per acre, one application per year.

Axoxystrobin (Quadris) – This fungicide was only applied to a few acres in 1999. It became available for commercial use in 1999 for control of early blight and late blight.

Integrated Pest Management:

Integrated pest management practices used by growers to reduce the incidence of diseases:

Disease Management	% Growers
Reduce source of late blight by destroying cull potatoes	96%
Plant certified seed	94%
Scout for late blight	98%
Sort/remove decayed tubers coming into storage	88%
Adjust fertility/irrigation practices to manage diseases	86%
Control weeds that are alternate hosts of diseases	82%

Post-harvest Potato Storage:
Most of the U.S. fall potato crop is stored for later marketing and processing. To obtain a constant supply to the fresh and processed potato market, potatoes are treated with a sprout inhibitor. The potatoes are treated with sprout inhibitors at least two weeks after going into storage. Typical treatment may apply sprout inhibitors later into storage usually in December.

Control:

Chlorpropham (CIPC) - This is the most effective post-harvest sprout inhibitor registered. It is applied to 70% of stored potatoes. It is applied at the rate of one gallon per 600 cwt.of potatoes, one or two applications per year. If the alternative, maleic hydrazide, is used, the storability of the fall potato crop would be reduced by three to six months.

Maleic hydrazide – A foliar sprout inhibitor applied during the growing season. Applied to 15% of acres. It is applied at the rate of 3 pounds active ingredient per acre, one application per year.

Diseases such as late blight are treated in potato storage facilities by applying a disinfectant to the treatment water or humidification in the storage facility plenums. Post-harvest potato disinfectant dips are also available with most having a potable rinse requirement. These are often used in flume waters or directly on the potatoes. Examples include: calcium hypochlorite, peroxyacetic acid/hydrogen peroxide

and chlorine dioxide.

Control:
Chlorine dioxide (Purogene and Anthium AGP)– This disinfectant is used in Idaho under a Section 18 Emergency Exemption provision of FIFRA. One application per year may be made directly to potatoes going into storage. It can also be added to the humidification system as either a mist in to the air stream or as a fog directly into the storage facility plenums. This treatment can be made up to five times per month of storage.

Nematodes

Nematodes are one of the major limiting factors for potato production in Idaho. Nematode infestation results in yield decline and reduction in quality thereby contributing economic loss to the industry. Predominant nematode pests identified in rhizospheres of potatoes are root knot nematodes (*Meloidogyne* spp.), root lesion nematodes (*Pratylenchus* spp.) and stubby root nematodes (*Trichodorus* and *Paratrichodorus* spp.)

Root-knot nematode
Meloidogyne spp.

Columbia root-knot nematode and the northern root-knot nematode have been recognized as major nematode pests on potato and found in abundance especially in sandy soils. Females feeding in the tubers and the development of live young cause enlargement or bumps in the outer layers of the tubers, rendering them useless for either fresh packing or processing. The nematodes have a wide host range leading to population increases when other susceptible crops are grown in rotation with potatoes. Damage is usually most severe following alfalfa hay crops and during years with high spring temperatures. Specific symptoms caused by root-knot nematodes include swellings, called "galls," on the roots. These galls may contain one to several adult root-knot females. They cause field damage that is localized, usually in patches of various sizes, or may be spread throughout an entire field and plants become chlorotic and stunted. Damaged roots are not able to obtain soil nutrients and above ground symptoms appear as nitrogen or micronutrient deficiencies. Plants may wilt easily, especially in warm weather, due to root damage even though soil moisture may be adequate.

Root Lesion Nematode

Pratylenchus spp.

The root lesion nematode *Pratylenchus,* a migratory endoparasite on potatoes, is a concern to potato growers because it reduces yield by indirectly weakening and increasing plant stress. This stress causes the potato plants to be more susceptible to fungal and bacterial diseases. There is also a correlation of root lesion nematodes with the incidence of verticillium wilt (early die). Five percent of the growers consider this pest to be important.

Stubby Root Nematodes

Trichodorus spp. and Paratrichodorus spp.

Stubby root nematodes are migratory ectoparasites and are found in sandy, moist, cool soils. Damage is profoundly influenced by soil moisture and is greater in wet seasons. These nematodes are important parasites of potatoes, not so much for the direct damage they cause but for the tobacco rattle virus they transmit to potatoes. This virus causes a disease of potato tubers called corky ringspot. Rusty brown, irregularly shaped lesions that have a corky texture appear in the flesh of the tubers. Nematode problems occur mostly in isolated sandy soil areas of southern Idaho. These nematodes have wide host ranges, making management with crop rotation difficult and relatively ineffective. Stubby root nematode is mobile in the soil and may traverse large vertical distances; therefore, enumeration and determination of a threshold level is difficult. They may survive cold winters by migrating below the frost line and undergoing dormancy.

Control:

Control of nematodes in the potato field can be achieved by chemical and non-chemical means. Non-chemical practices include prevention, crop rotation, clean fallow, early harvest application of organic manure and catch crops. Soil sampling is used by 51% of growers to determine the level of nematode infestation. When nematode population densities exceed the economic threshold, chemical nematicides will be applied by most growers.

Chemical Control:

Fumigants and non-fumigants are the two types of chemicals used for the nematode management. Fumigants are volatile compounds that produce toxic fumes when injected in to the soil. Non-fumigants are nonvolatile compounds that kill nematodes by direct contact.

Fumigants

Soil fumigation is the most cost effective chemical method for controlling root-knot nematode.

Metam Sodium (Vapam, Metam, Busan) - This fumigant is applied to 30% of acres at an average rate of 40 to 60 gallons per acre. It is applied at 52 to 104 pounds of active ingredient per acre with one application per year as a pre-plant treatment.

Dichloropropane (Telone- II) – This fumigant is applied to 15% of acres at an average rate of 15 to 25 gallons per acre.

Non-fumigants
Non-fumigant systemic nematicides are the most cost effective chemical method for controlling root lesion and stubby root nematodes.

Ethopop (Mocap) – This is applied to 20% of the acres at the rate of 1 to 2 gallons per acre, one time per year.

Aldicarb (Temik) – This is applied at the rate of 3 pounds active ingredient per acre to only 15 % of the acres. Due to the 150 day pre-harvest interval (PHI), most Idaho growers do not use this chemical. It is applied at 15 to 16 pounds active ingredient per acre, one application per year.

Non-Chemical Control:

- **Prevention:**
  Since prevention involves no monetary input it is the least expensive control measure. Using clean, certified, nematode free seed, avoiding contaminated water for irrigation and nondecomposed manure are the practices for effective nematode prevention.

- **Fallowing:**
  Fallowing can be accomplished through frequent tilling of the soil by disking, plowing, or harowing. Herbicides can be applied to prevent the weed growth. Repeated cultivation reduces nematode populations in the upper layer of soil by exposing them to heat and air. Cultivation also reduces the Rhizoctonia inoculum potential. Since weeds harbor nematodes, it is essential to keep the field weed free.

- **Early Harvest:**
  Planting early maturing varieties is a good practice to reduce the nematode population below the economic threshold level. A short growing period reduces the time available for nematodes to infect potato tubers and cause significant symptom development.

- **Organic Manure:**
  Application of organic manure affects the nematode in two ways. First, the manure produces toxic fumes and chemicals that kill nematodes, and second, it increases the activity of naturally occurring biological control agents in the soil.

- **Catch Crops:**
  Planting oil radish and rapeseed green manure crops in the fall before planting the potato crop in the following spring is an effective nematode management practice.

  After green manure incorporation and before potato planting, the nematode population densities decline with the oil radish green manure treatment. Green manure treatments support greater potato yield and reduced nematode tuber infection compared to the fallow treatments. Oil radish is the most effective of the green manure treatments.

Weeds

Weeds are considered one of the three most serious pests in potato production. Weeds can cause a 15% or more yield loss if not controlled. Pigweed and barnyardgrass, for example, at a density of 1 plant per yard of row can reduce potato yield by 19 to 33%. Cultivation for weed control has been shown to reduce yields. A study done with two post-hilling cultivations reduced U.S. No. 1 potato yield by 17%.

Volunteer Grain

Volunteer grain can be a problem before planting.

Control:

Chemical Control:

Paraquat (Gramoxone Extra) – A nonselective herbicide applied before the crop is planted. Provides good control if volunteer grain has adequate growth. Applied on one percent of the acres at an average rate of 0.47 pounds active ingredient per acre plus a non-ionic surfactant.

Glyphosate (Roundup) – A nonselective herbicide applied before potatoes are planted. This herbicide is especially effective when volunteer grain is less than 6" tall. Applied on 5-10% of the acres at an average rate of 0.280 acid equivalents per acre. Glyphosate is also used to control annual grasses and perennial grasses such as quackgrass.

Grasses and Broadleaf Weeds

Primary target weeds include nightshade (host of CPB), redroot pigweed and several other broadleaf and annual species. Several control options are possible, both chemical and cultural.

Growers mound soil around the potato plants, a process called hilling. This helps to reduce greening, which occurs when the tubers are exposed to light. Some herbicides are incorporated into the soil during hilling. Cultivation is used by growers to control weeds and keep tuber greening down. If performed correctly, cultivation, with no weather delay is an effective weed control measure. However, due to the nature of weed growth and weather patterns, chemical measures are almost always a necessity. In addition, crop damage can be more severe with cultivation than with herbicides. The combination of herbicides and cultivation is essential in the production of potatoes.

Control:

Chemical Control:

Metribuzin (Sencor, Lexone) - An efficacious herbicide used by 83% of growers. This herbicide can be applied pre-plant incorporated, post-plant before weeds and plants emerge, or post-emergence before weeds are 1" tall. Some potato varieties are sensitive to metribuzin and may be severely injured. Metribuzin is applied to 75% of acres at the average rate of 0.5 pound active ingredient per acre, one application per year.

EPTC (Eptam) -. This herbicide can be applied pre- or post-plant plus pre- or post- emergence of the crop. It is applied by ground equipment or by chemigation. Provides good weed control. EPTC is applied to 55% of the acres at the average rate of 3 pounds active ingredient per acre, one application per year.

Pendimethalin (Prowl) - Used by 20% of growers. Applied to pre-emerged weeds and before potatoes are 6" tall. Can be applied by air, ground equipment, or chemigation. It requires incorporation by cultivation or by irrigation. Applied to 22% of acres at an average rate of 0.77 pound active ingredient per acre, one application per year.

Metolachlor (Dual) - Applied before or after planting or after final hilling; but only if weeds and crop have not yet emerged. Applied to 10% of the acres at the average rate of 2 pounds active ingredient per acre, one application per year.

Rimsulfuron (Matrix) – Used by 16% of the growers. A very active herbicide on certain weed species. Works well on weeds after they have emerged. Can be applied by ground equipment or chemigation before weeds are 4" tall and potatoes 6" tall. Applied to 16% of the acres at the average rate of 0.02 pounds active ingredient per acre, one time per year.

Sethoxydim (Poast) – Used as a post emergence grass control. Most effective on actively growing grasses. Sethoxydim is applied to 2% of the acres at an average rate of 0.28-0.38 pounds of active ingredient plus crop oil concentrate per acre.

Glyphosate (Roundup) – Used on 5-10% of the acres for control of annual grasses and perennial grasses such as quackgrass. Glyphosate is also used for control of volunteer grain. The average rate is 0.28 acid equivalent per acre.

Integrated Pest Management and Cultural Control:
The following IPM and cultural practices are used by Idaho potato growers to reduce weed problems:

Weed Management Practice	% Growers Using Practice
Cultivate for weed control	88%
Scout fields for herbicide need	80%
Adjust herbicide rate based on weed pressure	67%
Rotate herbicide classes to avoid resistance	65%
Choose rotational crops that compete with weeds	59%

Potato Vine Removal:
Potato vine removal before harvest is a common practice in Idaho. Removing vines three weeks before harvest allows stolens to loosen from the tubers, hastens tuber maturity, and sets skin. The "skin set" trigger is the vine kill process. It takes about 18-21 days for tubers to completely heal after the skin set

process has started. A tough, fully mature skin provides excellent disease and bruise protection. The tough skin is also crucial to providing a quality crop during harvesting and storage. Since 90% of the potatoes are stored either on the farm or by processors and fresh pack shippers, minimizing storage loss is economically very important. Tuber maturity reduces water loss during storage, increases resistance to scuffing, decreases storage decay and increases resistance to bruising during harvest and handling. Because of the short growing season in Idaho's production regions, vine removal requires the use of chemical dessicants or mechanical vine choppers to aid in harvest before freezing temperatures damage tubers in the soil. About 60% of growers use some type of vine removal practice.

Mechanical vine killing techniques consist of rolling to crush the vines and open the canopy or mowing, usually with a flail-type mower, to chop the vines. Many growers use a combination of methods to kill vines in order to increase the speed and the effectiveness of the vine kill. One technique used in Idaho is to pull a flail-type mower with hill-hugging rollers behind it through the field and follow this with a chemical application two or three days later.

Chemical Dessicants:

Diquat- This is applied to 16% of the acres. The average rate is 0.35 pounds active ingredient per acre with one application per year.

Sulfuric acid- This dessicant is applied to 28% of acres at the average rate of 275 pounds active ingredient per acre, one time per year.

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