FIELD SELECTION, CROP ROTATIONS, AND SOIL MANAGEMENT

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CROP ROTATIONS AND SEQUENCES

Cropping sequence and length of rotation play an important role in potato production. Too often, growers are forced to base their cropping system decisions on short-term economic survival. Our market-based economy rewards economic efficiency and has helped push the trend to larger farms, with lower production costs. Improving economic efficiency with large, specialized potato equipment means farming more potato acres. If the farm size can't be increased, then the rotation must be shortened to get more potato acres. But shorter rotations can drive up input costs and reduce yield and tuber quality and, what appeared to be a good economic decision, often turns out to be a cropping system that is not sustainable. It is a mistake to assume that yield, tuber quality, and input costs will remain static as rotations are shortened.

Many factors need to be included in the cost of production estimates that all farms should be calculating as they consider length of rotation and cropping sequences. These factors include yield and tuber quality loss due to increased pest damage and decreased soil health, as well as increased operating costs in response to these negative impacts. It is also important to consider the risk of development of pesticide resistance in poorly designed cropping systems. Risk of development of pesticide resistance is much greater as the years between potato crops decreases and if pesticides of the same mode of action are used in the potato and the rotational crops. Truly sustainable cropping systems must balance agronomics and economics over both the short and the long term.

Weeds

Ideally, the potato crop will be planted into soil from which the majority of the weed seed bank has been depleted. Cropping sequence choices may impact weed-related issues in potato production. Since broadleaf weed control in grass crops is usually not as difficult as controlling broadleaf weeds in broadleaf crops, multiple years of grass crops between years of potato production can be a cost effective means of reducing broadleaf weeds commonly found to be a problem in potatoes. The use of different modes of action from year to year is recommended to prevent or delay the development of herbicide-resistant weeds. An increase in length of time before potatoes are again planted in a field usually increases the opportunities to use herbicides with different modes of action than what is used in potatoes. However, just because a herbicide is not used in potatoes doesn't mean that it always has a different mode of action than a potato herbicide.

In addition to herbicide resistance issues, length of rotation can impact weed control and potato production costs. Short rotations can increase the occurrence and/or density of weed species that are hard to control in potatoes. Severe weed pressure, especially from weeds that are problematic in potatoes can increase control costs and the incidence of weed escapes. Potato tuber quality and yield are reduced by weed competition and, as a result, net returns are reduced. Fields with severe weed pressure may require an increase in the application rate(s) and/or the number of herbicide applications (i.e. an unplanned, post emergence rescue treatment may be necessary if early-season weed control is not adequate).

Disease

Overall, growing potatoes in a field more frequently than three to four years will increase the likelihood of soil-borne diseases, especially for white mold, (*Sclerotinia sclerotiorum),* pink rot (*Phytophthora erythroseptica),* pythium leak (various *Pythium* species), verticillium wilt (*Verticillium dahliae),* and powdery scab (*Spongospora subterranea* subsp. *subterranean)*.

As the time between susceptible hosts increases, the pathogen population decreases. However, all of these pathogens can survive through three-year rotations. Growing potatoes on a one or two year rotation will lead to greater problems with white mold, pink rot, and Verticillium wilt; compared to growing potatoes in a three plus year rotation. Because organisms causing Verticillium wilt, white mold, and powdery scab can live in the soil for several years, normal rotations (3-4 years) may not have any significant effect. Observational data indicate that longer rotations (3 or more years between potato crops) can reduce pink rot.

As far as rotation crops as alternative hosts, dry beans and canola are susceptible to white mold. Growing these crops in rotation with potatoes can increase the severity of white mold. Verticillium has many alternative plant hosts, such as mint and many weed species. Fortunately, the main crops grown in rotation (small grains, sugarbeets, alfalfa, dry beans, and corn) with potatoes in Idaho are not alternative hosts for Verticillium.

Insects

Rotating crops is one of the most effective cultural control practices to reduce potato insect populations. Potato insects that over-winter in soil or on crop residue have increased populations as the frequency of potatoes increases in the rotation. Increasing the frequency of potatoes in the rotation also results in increased incidents of volunteer potatoes in rotational crops, acting as a host and launch site for flying insects, such as Colorado potato beetles. Planting cereal grains after potatoes aids in reducing migrations from overwintering sites to new fields.

Cropping sequence also impacts insect pressure. Avoiding rotations that include clovers and grasses may reduce wireworm populations. Planting alfalfa may reduce wireworm populations. However, leather jacket damage can be severe in potatoes following alfalfa, especially if the alfalfa is not plowed under until spring. Spider mites can be a problem following corn, bean, alfalfa, and clover seed if volunteer plant populations are high or if downwind from infested fields or along dusty roads.

As mentioned previously, a short rotation may increase the number of volunteer potatoes. Volunteer potatoes have been shown to be sources of both viruses and green peach aphid, which is the most efficient vector of potato viruses. Significant numbers of winged aphids can be produced in volunteer potato after plants have emerged. Aphids moving directly from volunteer potato plants in neighboring fields often transport viruses, since volunteer potato plants often have a high rate of disease infection.

Nematodes

Crop rotation and cropping sequence impacts nematode populations and are important considerations for the management of potato nematodes. Increasing frequency of potatoes in a cropping system results in increased pressure from nematodes. Increasing the time between potato crops, particularly with rotation crops that are poor hosts, results in reduced risk of nematode damage. In general, potato tuber yields are higher in rotational sequences that begin with wheat or barley than in the sequences that begin with potato, sugar beet or onion. However, small grain crops are a host for many nematode species. Infection damage from Columbia root-knot (*M.chitwoodi*) nematode tends to be worse in potatoes following a small grain crops as compared to corn or other poorly susceptible hosts. In contrast, damage from northern root-knot nematode (*M. hapla*) tends to be worse following alfalfa. Resistant alfalfa varieties, such as Archer II AmeriStand 444NT, AmeriStand 403T, Robust T&N and Roccus reduce populations of root-knot nematodes. Stubby-root nematodes have a wide range of hosts, including cereal crops. Host range studies for potato-rot nematodes have indicated that potatoes and snap beans are good hosts, red clover and corn are intermediate hosts, alfalfa is a poor host, and oat is a non-host. Green manure crops have also been shown to effectively reduce damage from nematodes.

Soil

Cropping sequence and rotation impacts soil chemical, physical, and biological properties, such as nutrient cycling, erosion potential, compaction, organic matter, and biological diversity and activity. Potatoes have a relatively high nutrient requirement and removal rate, which can deplete nutrients from the soil for subsequent crops without proper fertilization practices.

In addition to nutritional effects, increasing the frequency of potatoes in rotation increases the erosion potential. Erosion results in the loss of valuable topsoil that contains important physical, chemical, and biological properties that are not as prevalent in subsoil materials. Furthermore, the amount of organic matter being returned to the soil decreases as the number of low residue crops, such as potatoes, increases in the cropping system.

In addition to residue issues, potatoes typically have high levels of tillage. Tillage warms and dries the soil, resulting in an increase in chemical oxidation and microbial decomposition of organic matter. The net effect of tillage is a significant loss of soil organic matter. Tillage and organic matter loss also influence compaction.

Compaction is a major source of yield reduction in many soils. Harvest and tillage operations in potato production result in destruction of soil aggregates by physical breakage and loss of organic matter binding. Furthermore, field traffic, especially when wet, compacts the soil and results in less pore space for root, water, nutrient, and air movement. As mentioned previously, potatoes and other root crops have relatively more soil disturbance than most other crops. In addition, potatoes often require more trips across the field with heavy equipment. The net effect of potato production is an increased risk of yield loss from compaction.

These zones of high soil bulk density can decrease soil water-holding capacity, infiltration and drainage resulting in excessively wet and dry areas in the field and increased water run-off and erosion. Soil compaction also interferes with potato root and tuber growth due to increased mechanical resistance of the soil. As a result, potato plants growing in compacted soils are more susceptible to water and heat stress and typically have a higher proportion of malformed tubers and internal defects. Limitations on root growth coupled with poor soil water distribution can also hasten the onset of early dying and increase the incidence of rhizoctonia, silver scurf, pink eye and pink rot.

Finally, soil biology is impacted by both frequency of potatoes in the rotation and the cropping sequence. Although microorganisms can be both good and bad for plants, the best scenario is to have large numbers of diverse species of microorganisms. Repeated fumigation and low inputs of residues can decrease the total number microorganisms and the number of species present in the soil. The effects of fumigation on soil microbial populations seem to be most dramatic on soils with low base levels of organic matter.

TILLAGE

Selection of tillage operations will depend, to a large extent, on soil type and structure, soil erosion susceptibility, and energy costs, as well as on the residue management requirements of the previous crop. The tillage system should be designed to effectively incorporate crop residues, break up compacted soil layers and prepare the soil for planting while minimizing the potential for soil erosion.

Moldboard plowing has been used over the years as a primary tillage operation prior to potatoes, particularly on relatively flat ground where runoff erosion is not a significant problem. Plow depth varies somewhat with soil type and the amount and type of crop residue, but usually is about eight to twelve inches. Wet fields should not be plowed to avoid developing compacted layers at the bottom of the plow shear.

Fall plowing is usually preferred over spring plowing since it allows more time for crop residue breakdown. However, fall plowing can increase susceptibility to wind erosion due to the lack of crop residue on the soil surface. Fields that are plowed in the fall are often left with a rough surface over winter. However, some growers will also cultivate in the fall especially after broadcasting fertilizer or when fall bedding. Disks and/or roller packers are typically used for these secondary tillage operations. Fields that have only been plowed in the fall are usually disked and roller-packed or harrowed in the spring following broadcast fertilization.

Chisel plows, using chisel points or sweeps, are commonly used in the fall to break up hardpans and compacted soils and improve water infiltration during the fall and winter months. Grain fields are typically irrigated, chopped with a straw beater and then chisel plowed in the late summer after harvest. The grain stubble is then either disked or left standing over winter to improve soil moisture distribution and reduce erosion. Although a number of different types of chisel implements are used under a range of field conditions, sweeps are often used in fields where hard pans are a problem, while chisel points are preferred on sloping ground that is prone to erosion. In the spring, fertilizer is broadcast over the field, followed by disking, and harrowing. The beds are then established during the marking operation.

For chiseling to be effective, tillage depth must exceed compaction depth so that hard pans are adequately disrupted. Ideally, shanks should be set at an operating depth that will lift and shatter the compacted soil layer without exceeding the sheer stress value of the soil. Shank spacing should be set so that the entire surface layer of soil is disrupted by the tillage operation.

Following grain, some growers will disk the field twice in the fall at opposite angles. They will then establish beds and fertilize during the marking operation.

Fall bedding has increased in popularity in recent years. Fields are usually irrigated and fertilized and then chiseled or moldboard plowed prior to forming beds in the fall. Fall bedding allows for more of the soil preparation work to be done in the fall when conditions are usually good and more time is available. This provides additional time in the spring for growers to focus on the seed preparation, pest management and planting operations.

Dammer-diking, or reservoir tillage, is a tillage operation performed at the final cultivation that forms small catchment basins in the furrows. These basins are designed to increase water infiltration and reduce water run-off, which generally improves soil water uniformity across sloping ground. The basins also help to reduce soil erosion and surface movement of fertilizers and pesticides. When properly used, basin tillage significantly improves water use efficiency on sloping ground.

GREEN MANURES

Green manures are plant materials that are incorporated into the soil prior to maturity to provide some benefit to the following crop. Legumes are commonly grown as green manures in potato cropping systems. However, non-leguminous crops such as oilseed radish, yellow mustard and sudangrass have also been used effectively.

Some of the potential benefits of growing green manures prior to potatoes include: 1) contributions of biologically fixed nitrogen to potatoes and subsequent crops, 2) improved potato yield and quality, 3) improved soil physical properties and organic matter content, 4) improved water infiltration and soil water holding capacity, 5) suppression of soil-borne potato diseases, nematodes and weeds, and 6) improved soil erosion control with winter cover crops.

On the other hand, there are also some potential disadvantages associated with adding green manure crops to the rotation, including: 1) reduced income if the land is taken out of production for a year, 2) additional seed, tillage and irrigation costs, 3) additional labor and machinery requirements, 4) hosting of disease or nematode pests by the green manure crop if the wrong green manure is used, and 5) creation of an additional weed problem if green manure crops are allowed to produce seed.

Most Idaho producers do not want to devote an entire growing season to the production of a green manure crop. Consequently, a reasonable approach for including green manure crops in a potato rotation is to grow the crop in the fall following the harvest of the previous crop and incorporate the residue in the fall or spring before planting potatoes. The length of the fall growth period is much greater in southwest Idaho than in the eastern part of the state. As a result, the type and potential biomass of green manure crops that can be grown are much greater in southwestern and south central Idaho. In eastern Idaho, only fast-growing, cool-season green manure crops such as oilseed radish and mustard can be assured to produce sufficient biomass to have a significant effect on the following potato crop.

Selecting a Green Manure Crop

The ideal characteristics for a green manure crop to be included in a potato rotation include: 1) frost tolerance and the ability to grow well under cool fall conditions, 2) capability of quickly producing substantial amounts of biomass, 3) the ability to fix nitrogen and/or suppress soil-borne potato pests, 4) compatibility with the management requirements of other crops in the rotation, 5) herbicide tolerance and limited pest control requirements, 6) availability of seed and a lack of planting restrictions, such as the restriction of rapeseed production in Canola districts and 6) the ability to avoid producing and shedding seed that leads to problems with volunteer plants.

Cultural Management of a Green Manure Crop

To achieve the best results, green manure crops should be planted as early as possible either in spring or late summer. An eight to ten week growing period with soil temperatures above 60º F is critical. With the advent of oil radish varieties that mature earlier, length of the necessary growing period may be shortened in the near future.

To obtain best results for establishing a green manure crop following a cereal crop, the field should be prepared by removing the straw (baling, burning residue, or chopping) and preparing the soil immediately after harvest. If time permits, irrigating should help germinate volunteer grain and weed seed. Controlling the volunteer cereal plants and weeds will also help maximize nematode control. Soil should be loosened deep enough to allow dense root penetration and optimal aeration for egg hatching. This can be achieved by disking 2-3 times. Standard seedbed preparation is recommended.

Better nematode control will also be obtained when a minimum of 50 lbs of nitrogen per acre is applied to the green manure. This rate is recommended, since nitrogen aids in the decomposition of straw and enhances green manure establishment.

Choosing the appropriate variety of green manure is very important since the level of resistance varies among the different varieties of oil radish and white mustard. The recommended seeding rate is 25 pounds per acre. A dense seeding rate is needed to reduce competition with weeds. Sowing options include using a grain drill and packer and planting at a ½–1 inch depth or using a fertilizer spreader. If the seed is mixed with the fertilizer in a fan spreader truck, a light harrowing would be necessary to cover the seed.

Adequate soil moisture is important for green manure crop root establishment. Good irrigation practices will also help to maintain good aeration in the soil and promote seed germination. The number of irrigations depends on the soil type and profile, but a minimum of 3 to 4 irrigations is usually recommended.

To enhance weed control, the field should be irrigated and later disked if time permits. Other tactics include using a high green manure crop seeding rate and applying labeled herbicides. Treflan is a herbicide that can be used as a pre-plant application for broadleaf weeds and grasses, including grains. Assure 2 or Poast can be applied post-plant, and are effective against grasses (including grains). Herbicides should be used according to the labeled recommendations.

To prevent seed production, it may be necessary to mow at the pod formation stage (when plants are about 12 inches in height). It's important to prevent moisture loss during this period. To incorporate, the green manure should first be chopped, turned, then plowed or disked under to mix the green foliage and the roots with the soil. Plowing alone is not recommended because it results in uneven distribution of the plant material. Disking 2 to 3 times, plowing, or ripping and harrowing are recommended practices to incorporate plant residue.

Trade names are provided for clarity and do not constitute an endorsement of the product.