MEASURE AND MANAGE

Potato Quality Management

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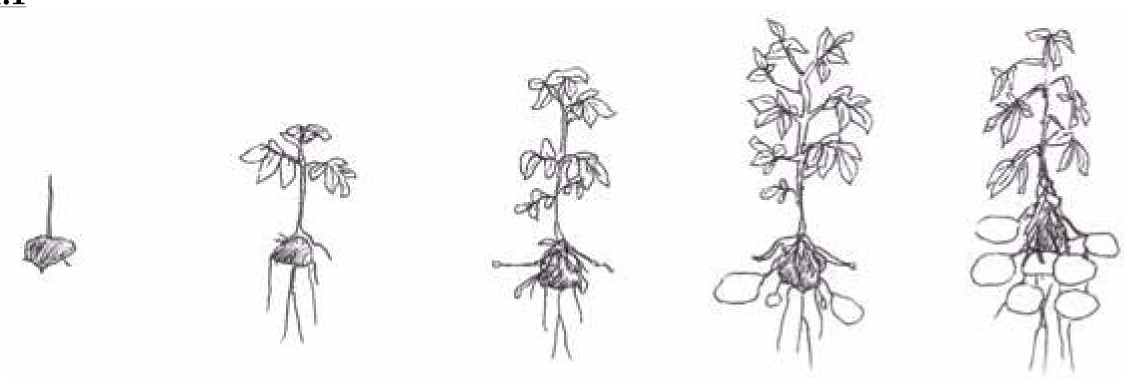
Agriculture on a worldwide scale is undergoing many fundamental changes. We have shifted from simply maximizing gross yield to considering maximum economic return, food safety and environmental concerns. Quality of the product we produce is of the utmost importance. The pursuit of quality is pushing today's agriculture toward more management intensive systems, therefore a more holistic approach is necessary to produce the desired result.

There is no one correct way to grow potatoes; local management, soil type and climate dictate the requirements to produce quality. We will therefore state the basic principles involved in potato production.

The Healthy Potato Plant:

A healthy potato is one which grows and develops without experiencing any limiting factors that reduce quality or economic returns. To understand what is required we can break the development of the potato into five stages.

Table 1.1



Growth Stage 1: Sprout Development	**Growth Stage 2: Vegetative Growth**	**Growth Stage 3: Tuber Initiation**	**Growth Stage 4: Tuber Bulking**	**Growth Stage 5: Maturation**
Sprouts develop from eyes on seed tubers and grow upward to emerge from the soil. Roots begin to develop at the base of emerging sprouts.	Leaves and branch stems develop from aboveground nodes along emerged sprouts. Roots and stolons develop at belowground nodes. Photosynthesis begins.	Tubers form at stolon tips but are not yet appreciably enlarging. In most cultivars the end of this stage coincides with early flowering.	Tuber cells expand with the accumulation of water, nutrients and carbohydrates. Tubers become the dominant site for deposition of carbohydrates and mobile inorganic nutrients	Vines turn yellow and lose leaves, photosynthesis decreases, tuber growth slows and vines eventually die. Tuber dry matter content reaches a maximum and tuber skins set.

Table 1.1: Adapted from Western Regional IPM Project, 1986, Integrated Pest Management for Potatoes in the Western United States, Publication 3316, Division of Agriculture and Natural Resources, University of California, Oakland.

Potato Quality Management from Emergence to Harvest

A healthy potato plant will carry out all of its functions during the five growth stages to the maximum ability allowed by genetics. However, rarely do we experience perfection, as there are always a number of factors that limit potato health and quality such as environmental, competition from weeds, insects and diseases.

Growth Stage 1:

Management practices during the first two weeks after planting focus on weed control. Little can be done at this stage for insects or diseases.

Soil factors prior to this stage that influence growth are soil structure, water holding capacity, aeration, drainage, temperature and nutrient levels. Sandy and sandy loam soils rich in organic matter are the most desirable soils. Soils having at least 50% pore space are best suited for maximum production. pH should be between 5.0 to 5.5, acidic soils tend to lessen scab diseases. Potatoes can be successfully grown at higher a pH providing that proper consideration be given to nutrient availability.

Water management prior to emergence is critical for maximum production. Saturated soils favour seed piece decay caused by bacteria pythium. In soils where excessive moisture is a problem, attention must be paid to using high quality seed and seed piece treatments.

Soil testing and detailed field mapping of nutrients is becoming an absolute necessity. In order to assess additional fertility needs, both soil test levels and field variability are required. Composite soil samples of large acreages are proving not to represent any particular area of the field. In order to maximize return, grid sampling and site applications are becoming the norm.

Soils test levels for P and K must be in the high range, 50 ppm and 200 ppm respectively. Consideration must be given to magnesium levels. Attempts must be made to maintain a K to Mg ratio of 1:2. As well, calcium should be maintained at the 70% Base Saturation level.

Nitrogen is the most difficult nutrient to recommend and control and is the most critical for potato quality. Enough needs to be applied pre-plant to provide for an even steady growth and suppress diseases from nutrient stress. With the exception of short season varieties, nitrogen is most efficiently used in split applications. Generally 1/3 to 2/3 of the N can be sidedressed after plant emergence with all sidedress within 60 days of emergence. Split applications of N provide for fewer tuber disorders such as hollow heart, brown centre, knobby or misshapen tubers.

Growth Stage Two:

During this stage leaves and branches are developing, roots begin to take up nutrients from the residual soil base and fertilizers. As the plants emerge, any problems with stand establishment should be noted. Primarily rhizoctonia stem canker or seed piece decay should be noted and investigated for future management review. Poor stands may have to be replanted at this time. Adequate water is critical at this stage for irrigated fields. 60 to 65% available water should be maintained. Excessive moisture may favour blackleg or promote verticillium. Nitrate leaching may also occur.

Hilling during this stage regardless of planting depth should maintain a cover of 6 to 8 inches on the seed pieces. Adequate hilling before row closure assures less sun scald and blight infections. Mechanical damage and transmission of viral diseases is also reduced. Root pruning is also a consideration at this stage. Pruned roots leads to tip burn which may be mistaken for late blight lesions.

Insect scouting also begins at this stage. Key insects are Colorado Potato Beetle, Aphids, Leafhopper and Flea Beetles. Pesticide treatments need to be determined based on threshold levels. Threshold levels vary with growth stage and production regions. Seek local advice.

Growth Stage 3:

This growth stage is very short, lasting only 10 – 15 days. Tubers form at the end of stolon tips. Tuber initiation is best monitored by pulling plants and directly observing the formation. This period usually coincides with early flowering stage when few flowers are visible. Soil moisture is critical during this stage. If irrigating, maintain 80 to 90% available water. This favours rapid growth and limits development of scab and other disorders. Weekly petiole or plant tissue analysis begins at this stage to monitor the nutritional status of the crop. The fourth petiole or leaf from the top of the plant is the desirable plant part. All critical levels have been determined based on this leaf position. Sometimes foliar fertilization is used to raise nutrient content providing there is enough growing season left. This should by no means be a planned fertilizer option. Preplant application of fertilizer is the preferred practice.

Under irrigation, nitrogen may be applied continuously throughout growth stage 3 and 4 with rates determined by plant tissue levels. If N is over applied it may lead to excessive vegetative growth and a heavy canopy delaying maturity and developing a microclimate conducive to aerial stem rot, sclerotinia stalk rot, or late blight. Insect scouting continues throughout this period.

Growth Stage 4:

Tuber Bulking:

Tuber bulking proceeds in a linear fashion after tuber initiation. The majority of plant nutrients are taken up during this stage. Application of Nitrogen with irrigation is most effective. Irrigation in growth stage three may not provide sufficient root mass for uptake of sprinkler applied N. Maintaining 80 to 90% available water is critical at this time. Moisture stress during this stage may increase early potato dying condition. Heavy rainfall or excessive irrigation may promote leaching of Nitrate Nitrogen and deficient plants are most susceptible to early blight.

Excessive moisture encourages more foliage diseases such as aerial stem rot, sclerotinia tuber rot and enlarge lenticels which promote tuber soft rot. Erosion of hills may expose potatoes to greening and sun scald and predispose the tubers to blight.

Scouting of fields should be at peak activity. Insects and diseases require careful management and observation apply appropriate treatments when threshold levels are breeched. Soil sampling for nematodes should take place at this time (one month prior to harvest).

Growth Stage 5:

Maturity:

During maturation, vines die back slowly and lose their leaves, photosynthesis is reduced and skins set. A slow gradual maturity is desirable for top quality and reduced harvest damage. A mature tuber is high in total solids and low in reducing sugars and exhibits a good skin set.

Nitrogen applications should stop 4 to 6 weeks before harvest. Excessive Nitrogen promotes a reduced specific gravity and high levels of reducing sugars.

Vine killing may be necessary to assist in the maturing process. This stops tuber growth, stabilizes tuber solids and promotes skin set. A mature tuber is more resistant to mechanical damage and less likely to be affected by fungal and bacterial diseases through wounds in the skin. Most potatoes require 10 to 14 days after vine killing treatments to mature sufficiently to reduce damage at harvest.

Prior to harvest the soil moisture conditions and pulp temperature should be noted. 60 to 65% available water and 50 to 65 degrees Fahrenheit pulp temperature are optimal harvest conditions.

Table 1.2

Suggested ranges of nutrient concentrations in the fourth leaf from the top of the potato plant during growth stage 4.

	Low	Marginal	Sufficient
Petiole without leaflets*			
Nitrate Nitrogen **ppm	<10, 000	10, 000 – 15, 000	>15, 000
Phosphate phosphorus** ppm	<700	700 – 1, 000	>1, 000
Phosphorus %	<0.17	0.17 – 0.22	>0.22
Potassium %	<7.0	7.0 – 8.0	>8.0
Calcium %	<0.4	0.4 – 0.6	> 0.6
Magnesium %	<0.15	0.15 – 0.3	>0.3
Sulfur %	<0.15	0.15 – 0.2	>0.2
Sulfate Sulfur ** ppm	<200	200 – 500	>500
Zinc ppm	<10	10 – 20	>20
Boron ppm	<10	10 – 20	>20
Manganese ppm	<20	20 – 30	>30
Iron ppm	<20	20 – 50	>50
Copper ppm	<2	2 – 4	>4
Molybdenum ppm	***	***	***
Entire leaf (petiole plus leaflets)			
Nitrogen %	<2.5	2.5 – 3.5	>3.5
Phosphorus %	<0.15	0.15 – 0.25	>0.25
Potassium %	<2.25	2.25 – 3.50	>3.50
Calcium %	<0.30	0.30 – 0.60	> 0.60
Magnesium %	<0.15	0.15 – 0.25	>0.25
Sulfur %	<0.12	0.12 – 0.20	>0.20
Zinc ppm	<15	15 – 20	>20
Boron ppm	<10	10 – 20	>20
Manganese ppm	<10	10 – 20	>20
Iron ppm	<11	11 – 30	>30
Copper ppm	<2.0	2.0 – 5.0	>5.0
Molybdenum ppm	***	***	***

* Values for petiole concentrations are for Russet Burbank; those for the entire leaf are suitable for many cultivars.
** Concentration of soluble nutrient (ppm = parts per million).
*** Concentration unknown.

Table 1.3:

Tuber growth rates and nutrient use by selected potato cultivars during growth stage 4.

Cultivar	Average daily growth rate of tubers (lbs/acre)	Daily nutrient use (lbs/acre)		
		Nitrogen	Phosphorus	Potassium
Russet Burbank	850	2.5 – 3.6	0.37 – 0.54	2.8 – 3.6
Lemhi Russet	850	2.2 – 3.9	0.39 – 0.56	2.9 – 3.6
Centennial Russet	800	2.5 – 3.6	0.35 – 0.50	2.6 – 3.4
Norgold Russet	1, 070	2.7 – 4.0	0.47 – 0.67	3.5 – 4.5
Pioneer	1, 200	3.1 – 4.9	0.53 – 0.76	3.9 – 5.0
Norchip	700	1.8 – 2.8	0.31 – 0.44	2.3 – 2.9
Kennebec	1, 300	3.3 – 5.2	0.57 – 0.82	4.2 – 5.5
Red McClure	1, 000	3.4	0.50	3.3
Oromonte	1, 000	3.0	0.40	3.4
White Rose	860	2.9	0.35	4.5
Four Unspecified Cultivars (avg.)	800	2.8	0.28	4.2

Table 1.4:

Nutrient Deficiency Symptoms for Potato Foliage

Nitrogen	Entire plants may turn light green. Young leaves remain green; older leaves turn yellow to light brown and become senescent.
Phosphorus	Plants are stunted. Leaves are dark green and their margins roll upward. Some purpling occurs in pigmented leaves. The severity of leafroll increases as the deficiency increases.
Potassium	Plants may be stunted. Young leaves develop a crinkly surface and their margins roll downward. Leaves have slightly black pigmentation. Marginal scorching with necrotic spots may occur on older leaves.
Calcium	The youngest mature leaves roll upward and become chlorotic with brown spotting. Growing buds may die. In tubers, a brown discolouration develops within the vascular ring before symptoms appear on vegetation.
Magnesium	Young mature leaves are affected with interveinal chlorosis and brown spotting which develop into interveinal scorching and necrosis. Leaves near growing buds remain green.
Sulfur	The symptoms are similar to those of nitrogen deficiency, except that chlorosis develops first in young leaves. Affected leaves turn uniformly yellow.
Boron	Growing buds die. Plants appear bushy, having shorter internodes. Leaves thicken and roll upward. Leaf tissue darkens and collapses.
Zinc	Young leaves are chlorotic, narrow and upward cupped and develop tipburn. Other leaf suymptoms are green veining, necrotic spotting, blotching and erect appearance.
Iron	Young leaves are yellow to nearly white but not necrotic. Leaf tips and edges remain green the longest. Green veining occurs in leaves.
Manganese	Young leaves are affected with interveinal chlorosis and then grey and black flecking and leaf cupping. The fleck eventually develops into small dead patches.
Copper	Young leaves develop a pronounced rolling and then leaf tips wilt and die. Leaves remain green and are of normal size.
Molybdenum	Leaves turn yellow or greenish yellow. The symptoms are similar to those of nitrogen deficiency.
Chloride	Young leaves are light green, turn purplish bronze and may curl upward or appear pebbled.

Table 1.5:

Available soil water is the difference between the field capacity of a soil (the amount of water retained in the total soil pore space after saturated soil has been drained) and the permanent wilting point (the point at which plants can no longer obtain water from the soil and thus wilt and die). Allowable depletion is the point to which available soil water can be depleted without inducing plant stress. For potatoes, the soil must always be maintained above 60 – 65% of available soil water.

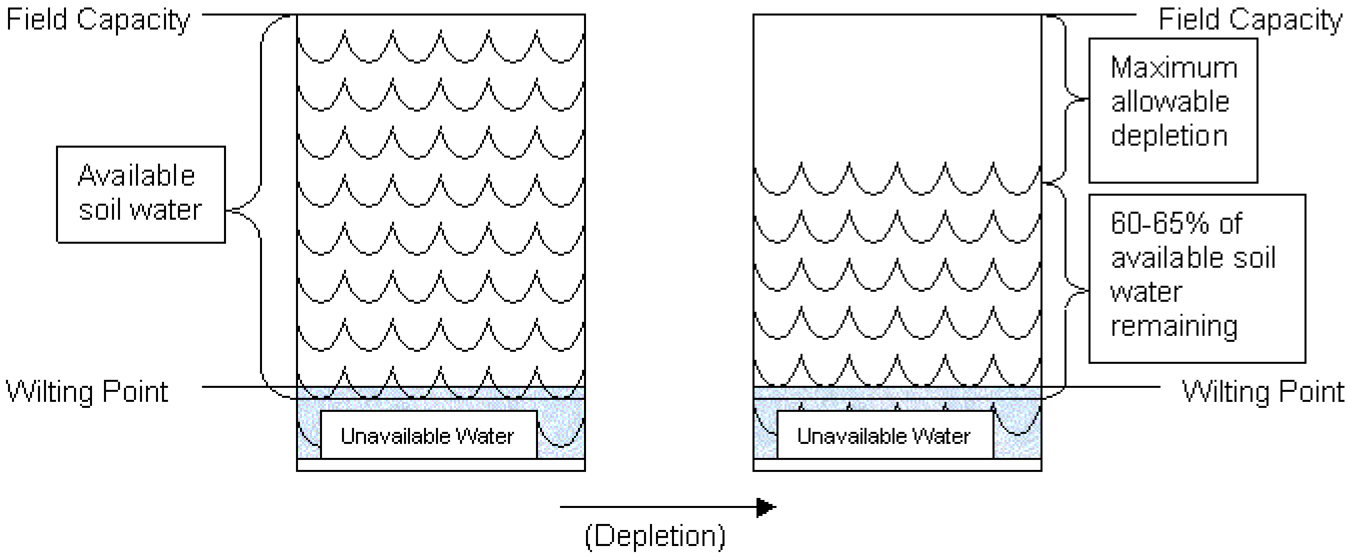
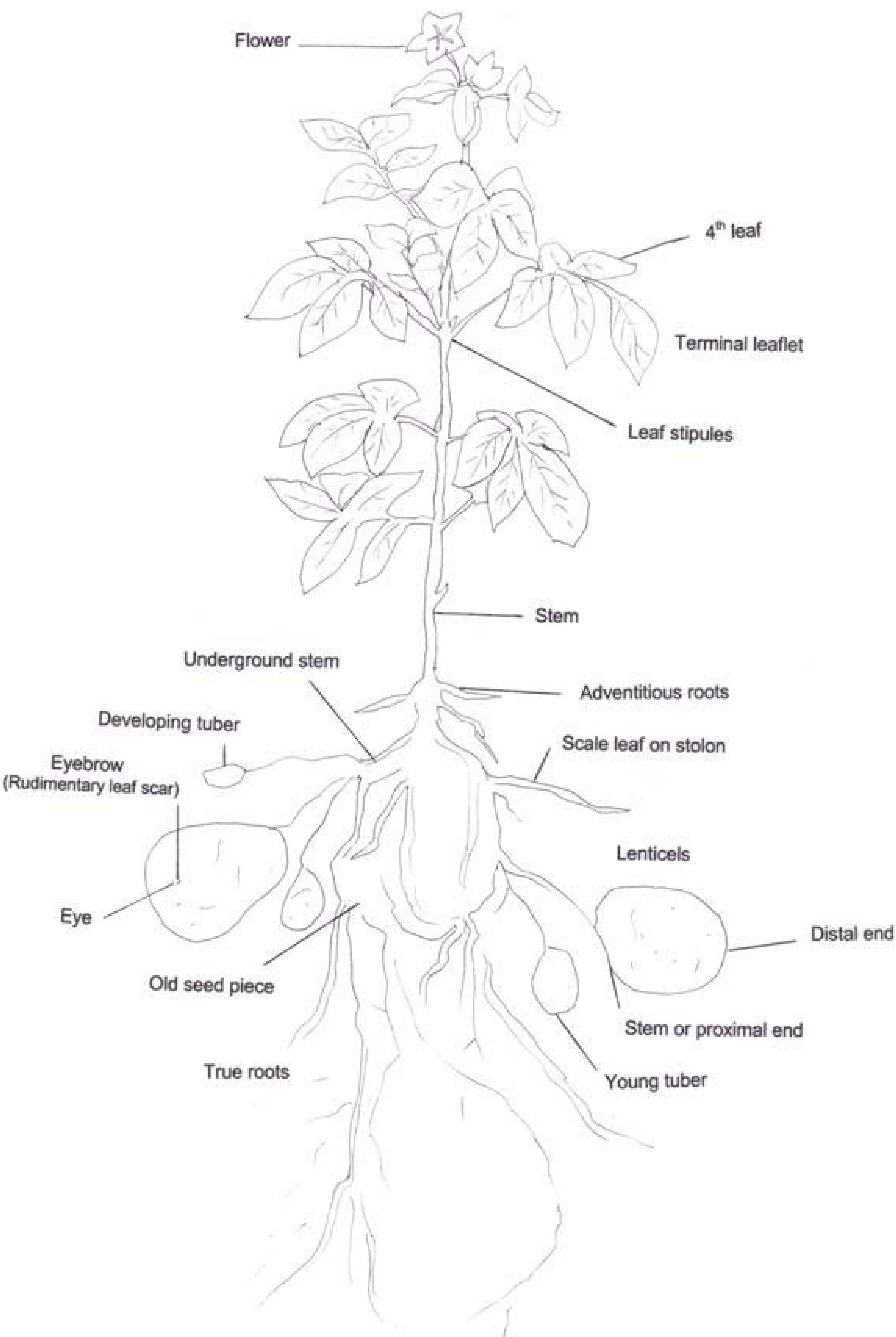

Field Capacity
Available soil water
Wilting Point
Unavailable Water
Field Capacity
Maximum allowable depletion
60-65% of available soil water remaining
Wilting Point
Unavailable Water
(Depletion)

Table 1.6:


Flower
4th leaf
Terminal leaflet
Leaf stipules
Stem
Underground stem
Adventitious roots
Developing tuber
Scale leaf on stolon
Eyebrow
(Rudimentary leaf scar)
Lenticels
Eye
Distal end
Old seed piece
Stem or proximal end
True roots
Young tuber