TECHNICAL NOTES

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WIND EROSION CONTROL IN WASHINGTON POTATOES

Mark Stannard, NRCS Interdis. Plant Sci. Spec.
Dr. Robert Thornton, WSU Extension Horticulturist

The intent of this note is to first, familiarize conservationists and technicians with the Washington irrigated potato industry, and secondly, relay information on applicable conservation practices to reduce wind erosion.

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- The Washington Potato Industry -

Washington grew 145,000 acres of potatoes in 1993 with a market value of approximately 350 million dollars (Hasslen and McCall 1993). Most the production is centered in Adams, Franklin, Grant, Walla Walla, and Benton counties. Washington ranks second in the nation in total tonnage of potatoes harvested. Washington potato yields far surpass other states and yields commonly exceed 500 cwt/acre.

There are basically four groups of potatoes produced in Washington. Each group is determined more or less by harvest date. ***The first group, table or fresh pack potatoes***, is planted very early in the spring, late February to early March. Harvest of these potatoes usually starts by July 10 and are shipped directly from the field to the packing sheds and onto the markets. The acreage is fairly small and the land is typically seeded to winter wheat for cover after harvest. Since these potatoes are planted so early, several weeks may pass before emergence. Soil erosion can be very high between planting and emergence.

The second group, direct-delivery potatoes, account for approximately 25% of the Washington potato acreage. These potatoes are planted a few weeks later in the spring and are harvested from early July to October. These potatoes are sent directly to the processing plants for immediate use. Winter wheat is typically planted on these fields.

The third group is the stored potatoes. Stored potatoes account for the majority of the potato acreage in Washington, approximately 60%. These potatoes are harvested from mid-September to the end of October. Commencement of harvest is governed by tuber temperature. If the tuber temperature is greater than 60F, harvest is delayed. Harvesting at warm temperatures requires extensive in storage cooling of the potatoes in order to prevent rotting while in storage. Winter wheat is typically planted in rotation soon after harvest. Cover may be lacking if the wheat planting is made too late into the fall.

Late potatoes is the last group. Late potatoes are harvested after October 20 and sent directly to the processing plants. Harvest date is determined by the demand (harvest call) from the processing plant and soil freezing potential. The soil is left bare over the winter because there are inadequate growing days left in the fall to establish a cover crop.

♦ Crop Rotation-

A high proportion of Washington potatoes are grown under contract. Many contracts call for the potatoes to be planted in a four year rotation. Three year rotations can occur and five year rotations are rare. A typical rotation would be:

Year 1 - Spring plant potatoes, harvest, seed winter wheat

Year 2 - Harvest winter wheat or destroy winter wheat, seed & harvest a cash crop
Year 3 - Seed & harvest cash crop (ex. corn or beans)
Year 4 - Seed & harvest cash crop (ex. corn or beans)

- **Potato Production Cycle-**

The residue from the previous crop is typically incorporated by plowing and/or disking soon after harvest. Fields with historic problems of nematodes will usually be fumigated in the fall with Telone^{tm} or Vapam^{tm}. Prior to fumigation with Telone, fields are worked with a harrow disk (finishing disk) in the fall to further bury residues, loosen the soil, and break up clods larger than 1-inch in diameter. Where subsoil barriers exist, deep shanking (ripping) is used to fracture the barrier. Inadequate field preparation hampers the distribution of the fumigants through the soil and increases the chances of loss of Telone to the atmosphere. The tillage practices associated with the application of Telone in the fall can lead to severe wind erosion on these fields because they typically go into the winter without adequate cover. Fields with historic problems with verticillium wilt are usually fumigated with Vapam or Telone C17^{tm}. Telone C17 is applied by deep shanking and requires soil preparation the same as when Telone is used. Vapam is applied through the sprinkler system and does not require the burying of surface residues. Deep shanking is desirable if a subsoil restrictive layer is present. Application of Vapam for verticillium wilt will generally occur in the fall before the water is turned off. Under extreme circumstances, both Vapam and Telone C17 are utilized on a single field.

Potatoes are generally planted in rows, 34 inches apart, and the seed pieces are spaced 8-12 inches within the row. Planting may begin as early as February and continue to as late as May.

Potato rate of emergence is dependent on soil temperature. Early planted potatoes may not emerge for 45 days if soil temperatures are below 45F. Normally potatoes require 20-25 days to emerge if soil temperatures are above 50F. It is during the time prior to emergence of the potatoes that wind erosion can be severe. It is not uncommon for potato hills to be completely eroded thus exposing the potato seed pieces. Producers will quickly re-hill the potatoes when this occurs. Clearly, a cover crop would be highly beneficial at this time providing that it did not compete with the potato crop.

After the potatoes have emerged, between-row cultivation to control weeds is quite often practiced. As part of this cultivation, special cultivator implements that move soil to reshape the potato hills are employed. Many producers use dammer-diker (basin tillage) equipment as a part of this cultivation operation.

Potatoes may be harvested from underneath green vines or from underneath vines that are dead due to chemical killing or "natural" senescence. Vines may also be mechanically topped to remove the vines. Vines can hinder the harvesting operations and result in an increase in damage to the tubers during harvest. Potato harvesting operations leave the soil relatively level and void of residue. There are however extensive machinery traffic patterns that usually require some tillage to reduce compaction. Harvested potato fields may be planted to winter wheat if there is adequate growing season left to establish a crop. The winter wheat crop may be left to be harvested the next fall, or destroyed the following spring to make way for a cash crop.

- **Weed Control-**

Weed control in potatoes is very intense. Between-row tillage and broad-spectrum herbicides are employed. The most commonly applied herbicide is metribuzin (Sencor^{tm} or Lexone^{tm}) which is applied post-emergence of the crop. Metribuzin readily controls weed seedlings already emerged and will control emerging weeds for several weeks after application. It is unlikely that a cover crop seeded at the time potatoes are planted would provide adequate cover to prevent wind caused soil erosion by the time metribuzin is generally applied. Other compounds such as Eptam^{tm}, Treflan^{tm}, and Prowl^{tm} are used less commonly. Treflan is applied preplant-incorporated thus excludes cover cropping. Eptam and Prowl are typically applied pre-emergent after planting through the sprinkler system. Eptam and Prowl control germinating weeds only. Cover cropping could be practiced providing that the cover crop was allowed to emerge prior to herbicide application.

- Erosion Control Practices-

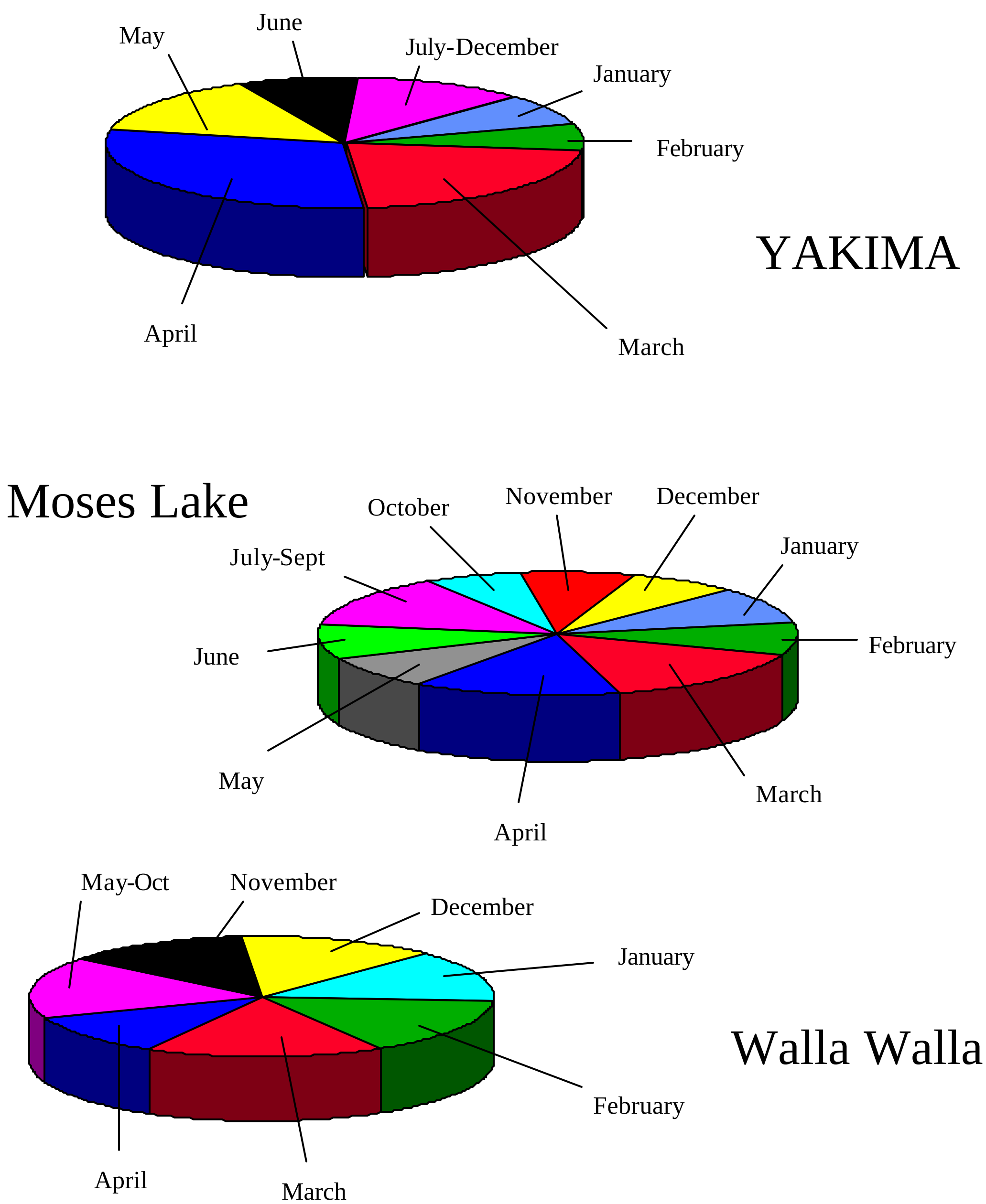
Wind erosion is a serious threat until the potato crop has developed enough foliage to protect the soil. There are basically 3 wind erosion periods: 1) after fall fumigation, 2) after spring planting of the potatoes, and 3) after the potatoes are harvested. All three periods are suspected of contributing to the fugitive dust problem.

The first period lasts roughly 4 months (late October to early March). Wind speeds exceed 60 mph are common and the amount of residue remaining on the soil surface after fumigation practices is inadequate to provide protection.

The second period is much shorter in duration, 20-45 days, for a given field but lasts from late February to early May due to the spread in planting dates. During this period, the wind erosion hazard is very severe. Highly erosive wind events commonly occur during March and April (Figure 1). Preparation of the soil for planting of the potato crop further reduces residue levels and any large clods of soil. Hilling does increase the surface roughness of the field but due to the distance between hills and the fact that many times the hills are not arranged perpendicular to the prevailing wind, any potential erosion control benefit is minimized.

The duration of the third period is quite variable. It may begin as early as September if a cover crop was not seeded after potato harvest or if a seeded cover crop did not develop adequately to protect the soil.

Figure 1. Monthly Erosive Wind Energy (EWE) for Yakima, Moses Lake, and Walla Walla, Washington.



♦ Reduced Tillage-

Reduced tillage is probably one of the more practical and effective practices for wind erosion control in the conservation practices arsenal. Reduced tillage retains more crop residue at the soil surface and slows the loss of soil organic matter. Some growers in the Red River Valley have been known to plant potatoes directly in unplowed grain stubble (Turnquist 1965). Reduced tillage could be utilized to control wind erosion occurring for all three wind erosion periods. Field fumigation with Telonetm is a major deterrent to reduced tillage because so little residue is tolerated when fumigating fields.

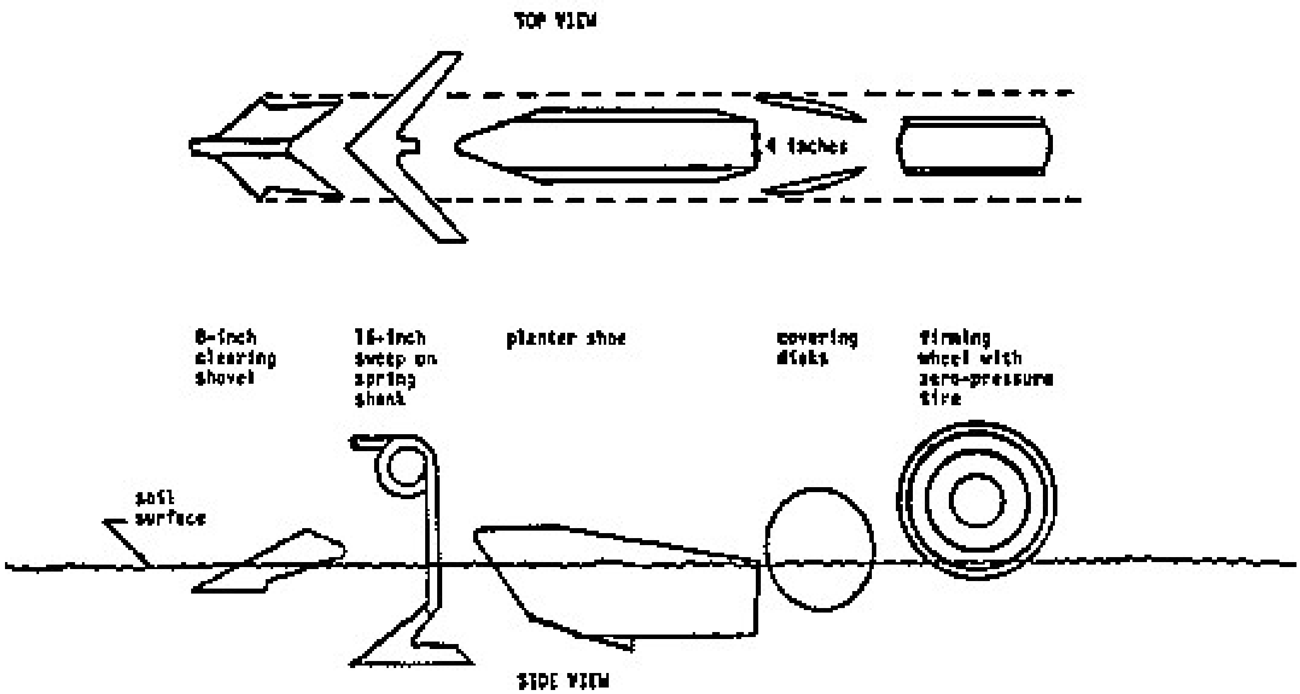
The primary emphasis in an effective reduced tillage program is maintaining as much of the available residue at the surface as possible (Pumphrey et al. 1978, Lumkes and te Velde 1974). Maintaining residue in the upper plow layer requires careful planning and management. Proper selection and operation of tillage implements is critical.

Considerable reduced tillage work was conducted in the 1970s by researchers at WSU. Drs. Hyde, Thornton and Kunkel determined that conventional planting equipment would readily plant potatoes into disked soil of low residue crops such as silage corn providing that the residue was maintained in the top 2-3 inches of soil, and away from the seed piece. Secondly, potatoes could be directly planted without causing planting difficulties if the crop residue was small and the planter was properly equipped. Thirdly, large amounts of loose residue increased planting difficulties. Firmly anchored residue was much easier to plant through. Loose residue pushed ahead, wadded up, and made the opening shoe of the planter ineffective. When a clearing shovel was added ahead of the opening shoe, anchored residue rolled to the side of the planting shoe enabling potato seed pieces to be placed into the furrow without difficulty.

A modified planter undercarriage capable of handling large amounts of residue designed by Hyde, Kunkel, Thornton, and Holstad is shown in Figure 2. The modification involved equipping a planter with a 8-10 inch lister shovel set to run just deep enough to split the residue and clear it to the side. A 16-inch sweep running behind the lister at 6-8 inches deep, loosened the soil, and undercut the residue 6-8 inches on each side of the seed row. The planting shoe was modified to reduce the number of projecting bolts to further reduce sites where residue could accumulate. The covering disks were set to pull soil only from the area cleared by the clearing shovel. The soil over the seed row was firmed over the potato seed pieces with a zero pressure firming tire.

They reported that between-row cultivation after planting tended to pile residue on top of the seeded row. A set of shallow running sugar beet knives mounted on the front tool bar of the cultivator prevented residue from piling on the seeded row. The knives needed to be staggered to prevent clogging. Wide sweeps were mounted on the second tool bar behind the knives for between-row cultivation.

Figure 2. Modified potato planter for minimum tillage potato planting.



Source: Hyde, Kunkel, Thornton, Halstad. 1977.

Potato harvest problems following reduced tillage ranged from none to severe depending upon the amount of surface residue or cover crop regrowth existing, and the time between planting and harvest. Early harvested potatoes had enough undecomposed residue to cause a problem, late harvested crops rarely had a problem. Green, soddy regrowth caused the most difficulty. Yields of reduced tillage potatoes equalled or exceeded yields of conventionally planted potatoes in on-farm trials. Furthermore, economic analysis showed that reduced tillage potato production was more profitable than conventionally produced potatoes (Hyde, Thornton, Kunkel 1978, 1979).

- **Surface Roughening / Emergency Tillage-**

Surface roughening involves tilling narrow strips across a field. These tilled strips create ridges which can reduce wind erosion if they are constructed perpendicular to the prevailing winds. Surface roughening is not intended to be an enduring practice but it can provide a certain degree of soil protection for one or perhaps two wind storms. Surface roughening following potato harvest is not practiced to a large extent because Washington potato soils have very low aggregate stability. The ridges simply breakdown too fast to be effective. Plowing wet soils might produce more resilient ridges but plowing wet soils greatly increases soil compaction and clod formation. Soil compaction has been shown to greatly reduce potato yields. It would be safe to assume that this practice would not be employed.

- **Mulching -**

Spreading straw has been shown to greatly reduce erosion associated with furrow irrigation in many trials (Shock et al. 1988, Berg 1984, Miller and Aarstad 1983). A study conducted at the Malheur Experiment Station in Ontario, Oregon showed that straw spread at a rate of 790 lb/acre (5.4 lb/100 ft of row) reduced irrigation induced erosion from 18 to 3 tons/acre (Shock et al. 1988). The study also showed that irrigation water use efficiency improved considerably with straw applications. This study was conducted on heavier soils and would react somewhat differently than the sandy soils of the Columbia basin.

Straw mulch will reduce wind erosion providing that the straw is firmly anchored. Left unanchored, straw simply blows off the field to create other problems for the grower. Implements such as a crimper could be drawn behind a straw spreader to vertically pin the straw in place. Needless to say, this is an added expense to the grower. Straw is relatively inexpensive but the labor and equipment costs involved can be high. Clearly, it is much more cost effective to manage the crop residue already in the field.

Manure is a relatively inexpensive mulch if a source of manure is readily available. Soil loss estimates generated by the Franklin Conservation District (1993) show that manure spreading can reduce wind caused soil erosion as much as 9 tons/acre/year. However, soil losses in each case still exceeded tolerable levels (Franklin C.D. 1992). Manure rates needed to reduce wind erosion are quite high. Lumkes and te Velde (1974) reported that 10-15 tons of liquid manure provided adequate soil protection. Liquid manure should provide better erosion control than dry manure because it binds soil particles but the cost per acre will be higher due to the higher weight involved. Potato fields are subject to high nitrate losses and fall manuring could aggravate the problem (Kraft and Stites 1994).

♦ Cover Cropping -

Cover cropping is one of the best options available to decrease wind erosion on potato ground. Cover crops also serve to hold nutrients in place, act as trap crops for insect pests or reservoirs for natural enemies of crop damaging insects, and have allelopathic effects on weeds and diseases (Connell et al. 1994). Many Washington potato growers currently seed a cover crop following potato harvest to protect the soil. Cover cropping prior to planting potatoes is practiced less frequently. Potatoes can be planted directly into growing winter wheat cover (Cary et al. 1975). The economic feasibility of this practice is questionable.

A key factor in the success of fall cover cropping is seeding it early enough for adequate growth to occur. Delaying fall seeding even a few days can greatly reduce the amount of ground cover produced (Edwards and Sadler 1992). Increasing the seeding rates are not as effective as early seeding (Lumkes and te Velde 1974, Grant et al. 1983). October 20th has typically been the cut-off date for fall cover crop seedings in central Washington.

Recent advances in crop growth modeling are enabling conservationists to better predict the amount of growth of winter wheat. These ground cover predictions can greatly influence producers' selection of conservation practices. Oregon State University and the USDA Agriculture Research Service recently developed PLANTEMP[1/] which can predict the amount of ground cover provided by 'Stephens' winter wheat at various dates based upon seeding date, local temperature records, and seeding rate & equipment. PLANTEMP was developed as part of the tri-state STEEP (Solutions To Environmental and Economic Problems) program for use by NRCS conservationists, Extension agents , and others concerned with wheat development. The NRCS RUSLE software also provides an index of vegetative ground cover and is based upon many of the same parameters.

The amount of ground cover needed to protect the soil varies considerably and generally must be calculated on a field-by- field situation. Factors such as unsheltered distance, soil type, cropping practices, local climatic conditions, and several others all have a tremendous impact on the amount of cover needed to protect the soil from wind erosion.

[1/] PLANTEMP is a a microcomputer program provided by the OSU Extension Service. Copies may be obtained by contacting the Agricultural Communications office of OSU

NRCS Plant Materials Centers and others developed numerous cover crops prior to the advent of synthetic fertilizers and herbicides. Unfortunately, the vast majority of these plant materials are not adapted to late fall seeding coupled with cold, arid conditions. Winter wheat generally remains the cover crop of choice by Washington potato growers and 'Stephens' is the most commonly used cultivar. Winter wheat seed is readily accessible and inexpensive. It does not require extensive seedbed preparation, becomes established quickly, tolerates potato herbicide residues quite well, and can be harvested with standard equipment. Testing cover crops for the potato growing region of Washington has been rather limited.

Sporcic et al. (1993) established several cover crop trials in Eastern Washington to evaluate erosion protection, forage production and economic return. Fifteen cover crops and cover crop combinations were seeded September 28, 1992 in one of these trials. All of the seedings emerged within 13 days after planting with the exception of two turnip cultivars (Table 1). It was felt that the unseasonably cool fall weather prevented the establishment of both turnip cultivars. This strongly indicates that turnips are not good candidates for late fall seedings. Good winter snow cover protected the spring grains from freezing and dehydration damage with the exception of 'Monida' spring oats which winter-killed. 'Steptoe' spring barley and 'Grace' spring triticale both provided roughly 10% ground cover in late October and provided in excess of 30% ground cover by mid March. 'Stan 1' and '6600' winter triticale provided better ground cover and scored better than 'Stephens' winter wheat in fall and spring measurements. Annual rye performed very poorly.

The Aberdeen, Idaho Plant Materials Center conducted a similar trial and seeded 35 crops on October 20, 1992. Only 10 entries representing 5 species failed to emerge in the fall but emerged the following spring. Most of these 10 were materials used for covers in more humid environments (Table 2). Brassica species (yellow mustard, tyfon, rape, turnip, etc.), rye and triticale provided the most fall cover. Data collected the following year show the same brassicas providing approximately 75% ground cover. The triticales provided roughly 50% ground cover but weed suppression was much better than the brassicas. Peas and vetches did not perform well in this trial.

The Los Lunas, New Mexico PMC recently examined the possibility of screening potential cover crops in the lab using coleoptile growth under cold conditions as the key factor. Initial results indicate that winter wheat "cold lab" coleoptile growth does not correlate well with growth under field conditions. However, spring wheat "cold lab" coleoptile growth appears to correlate with percent cover in the field. Further testing is needed to determine if this technique has utility for screening other cover crop species. They also stated that northern great plains spring wheats; 'Butte 86', 'Stoa' and 'Newana', performed the best in their field trials. Cold tolerance was probably inadvertently bred into northern great plains spring wheats because they are typically planted in cold environments.

Table 1. Ground cover and qualitative rating of 15 different covers seeded September 28, 1992 near Pomeroy, Washington.

Treatment	----------Ground cover---------- (percent)				Qualitative Rating
	Oct 11	Oct 23	Mar 10	Apr 12	(1-9) 1/
Stephens Winter Wheat	1	6	36	75	6
Boyer Winter Barley	2	9	31	68	7
Stan I Triticale	3	15	41	91	9
Stan I Triticale + 6600 Triticale	4	9	45	91	8
6600 Triticale + Alfalfa	2	10	39	90	7
Jenkins Winter Triticale	2	9	31	84	6
Jenkins Triticale + Winter Peas	3	8	26	83	7
Jenkins Winter Triticale + Spring Triticale	1	10	24	84	6
Grace Spring Triticale	2	13	50	80	7
Steptoe Spring Barley	1	9	48	78	8
Penewawa Spring Wheat	1	9	32	66	8
Monida Spring Oats	1	__ 2/	-	-	5
Annual Rye Grass	1	7	12	37	3
Red Top Turnips	0	0	0	0	0
Forage Star Turnip	0	0	0	0	0

1/ 0 = No Erosion Protection; 9 = Excellent Protection
2/ Winterkilled

Table 2. Stand rating and canopy cover of 35 cover crops seeded October 20, 1992 at the Aberdeen Plant Materials Center, Aberdeen, Idaho.

Cover Crop	Stand Rating (1-9) 1/	Canopy Cover (percent)
Yellow Mustard	2	75
Tyfon	3	80
Brown Mustard	4	20
Sparta Rape	4	85
Forage Star Turnip	4	75
Humas Rape	4	80
Common Rye	4	60
Florida 201 Spring Triticale	4	45
B-81420 Winter Triticale	4	50
Crystal Spring Barley	4	winterkill
Ute Winter Wheat	5	40
Rhondo Turnip	5	80
Civasto Turnip	5	60
Premier Kale	6	75
Regreen Sterile Wheat	6	50
Seco Barley	6	35
Late Barley	7	30
Ajay Oats	7	25
Owens Spring Wheat	7	50
Mt. Barker Clover	7	winterkill
Aroostock Rye	8	55
Brewer Lentil	8	15
Schuyler Winter Barley	8	75
Purple Vetch	9	winterkill
Indian Head Lentil	9	40
Papago Pea	0	35
Sunwheat Sunflower	0	winterkill
Yellow Pea	0	40
Austrian Pea	0	65
Debrorah Sweet Brome	0	20
Hairy Vetch	0	15
Lana Vetch	0	winterkill
Hairy Vetch Common	0	60
Matua Brome	0	10
Puna Chicory	0	15

1/ 1 being best; 9 poorest; 0 no emergence

Strip Cropping -

Strip cropping has been used to some extent in center pivot irrigated fields of Nebraska for wind erosion control. Kanable (1994) stated that growers in northwest Nebraska are alternate-planting 65-foot wide strips of beans and corn. The corn foliage benefits the beans by reduces high velocity wind movement at bean canopy height. Secondly, corn residue provides better protection against winter soil erosion than bean residue.

This technology may have some application in Washington potato production. Irrigation scheduling, weed control and harvesting procedures need to be considered when designing an irrigated strip crop system. Furrow and border dike irrigation systems lend themselves better to strip cropping than sprinkle irrigation systems.

Herbaceous borders are commonly used in the wheat-fallow areas of the great plains. Tall wheatgrass is planted between each strip to slow wind velocities at the soil surface and decrease saltation. Washington potato producers typically utilize large fields to maximize efficiency. Annual crops such as corn might be more acceptable. Standing sweet corn stalks could reduce wind velocities at the soil surface during the erosive period.

- **Field Windbreaks -**

Field windbreaks are commonly used in the Columbia basin to reduce wind velocities around orchards and vineyards. They are used less commonly around field crops and rarely within fields. Large unsheltered distances associated with center pivot irrigation negate field border windbreak efficacy. Wind erosion reductions resulting form the implementation of this practice in potato fields will be minimal. Dividing fields with "permanent" borders will probably not be acceptable.

- **Non-vegetative Soil Stabilizers -**

The NRCS does not have a practice standard for nonvegetative soil stabilizers to reduce wind erosion. Soil stabilizers and crusting agents have been tested extensively for many years. A classic study conducted in 1963 evaluated the wind erosion protection offered by rock, various asphalt emulsions, starch compounds, latex emulsions, and wheat straw (Chepil 1963). Results of this study showed that most of the treatments were cost prohibitive. Recent advances in polymer chemistry technology is placing this practice within economic reach of potato producers. The efficacy of new polymers requires testing and validation.

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