TECHNICAL NOTE

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Cover Crops

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A cover crop is a crop that is not harvested or generally grazed but is grown to benefit the soil health and/or future crops in numerous ways.

Cover crops

- Reduce wind and water erosion
- Sequester carbon in plant biomass and soils to increase soil organic matter content
- Capture and recycle excess nutrients in the soil profile
- Promote biological nitrogen fixation
- Increase soil biodiversity
- Suppress weeds and other pests
- Provide supplemental forage
- Improve soil moisture management
- Reduce particulate emissions into the atmosphere
- Minimize and reduce soil compaction
- Improve soil tilth

Cover crops are commonly grown during or between primary cropping seasons. A cover crop is considered part of the crop rotation. There are several methods available to plant cover crops into existing crops: They include over-seeding, frost seeding, aerial seeding, broadcast seeding or drill seeding. There are many positive attributes of using drills to establish cover crops over broadcast seeding. Drills provide greater soil to seed contact with lower seeding rates. As the existing crop dies, sunlight penetrates to the soil, allowing the cover crop(s) to germinate and establish.

Fall planted hairy vetch

When mixing cover crop species, like small grains and peas, many references indicate splitting the rate in half; or splitting combinations to a 60:40 mix.

Fall Cover Crops

Nutrient contamination of ground water is a major concern throughout many areas of Idaho. Fall cover cropping effectively captures nitrogen that would normally leach deep into the soil profile, contaminating ground water. Its effectiveness hinges on several factors:

- First, the cover must be seeded as soon as possible after the preceding crop is harvested because growing degree days are the most limiting factor for fall cover crop growth. This is especially important for sudangrass as the first frost of the season will kill the crop. Cereal grains are usually very tolerant of cool fall temperatures.
- Second, soil incorporation of the cover crop should be delayed until spring. Spring incorporation allows over-wintered cover to continue nitrogen capture up until incorporation and prevents loss of nitrogen caused by fall-winter decomposition of the cover crop.
- Lastly, producers must be made aware of the economic benefit of fall cover cropping.

The literature often documents above ground biomass produced but research is limited on the amount of actual nitrogen available for the following crop. Most of the literature recognizes about 50% of the nitrogen in the above ground biomass as being available for the next crop. There is the ability to fix or capture as much as 125 lbs-nitrogen/acre in above ground forage. The literature generally does not report contribution of the root mass, although we know there is biomass and nutrients in the root system. If 50% of the nitrogen is available the first year then about 60 pounds of nitrogen can translate into a fertilizer savings worth roughly $25.00/acre for the following crop. These values are only estimates and a good soil testing program can help the producer fine tune the nutrient management plan.

Brassicas as Cover Crops

There are numerous brassicas that grow well throughout Idaho. Turnips, mustards, rapeseed, and camelina are a few examples. The brassicas are excellent cover crops for several reasons. They tend to be small seeded and do not require deep seed placement for establishment. This enables the use of aircraft to efficiently seed a large number of acres. Approximately 5 pounds of turnip seed will seed an acre. Wheat, in comparison, will require 90 pounds and the seed should be placed 2-3 inches deep. Mustards contain glucosinolate, a compound that gives the seed its "hotness". This compound can suppress nematodes in potato fields. In order to release the compound into the soil, the mustard cover crop must be either mowed or crushed, and then incorporated into the soil. This process is known as biofumigation and it is in practice in southern Idaho and Central Washington potato fields.

Fall planted mustard used as a biofumigant.

Legumes as Cover Crops

Legume crops fix atmospheric nitrogen into a form plants and microorganisms can use. In areas with nitrogen ground water problems, both legume and non-legume species can recycle existing soil nitrogen and reduce the risk of excess nitrogen leaching into ground water. Only particular strains of rhizobium provide optimum nitrogen production for each group of legumes.

Rhizobium nodules on pea roots.

Rhizobium is purchased by type or legume group. If seed is not inoculated when purchased, coat the seed with condensed milk, soda pop, or a commercial sticking agent to help the Rhizobium stick to the seeds. *See Idaho Plant Materials Technical Note No. 26 for additional information on nitrogen fixation and Rhizobium.*

Incorporating cover crops will aid in the amount of nitrogen kept in the system. Many no-till operations kill the cover crop with herbicides or rollers and plant the following crop into the cover crop residue.

Legume cover crop species with associated agronomic data

Species **Legumes**	Life Cycle	Potential Fixed Nitrogen (lbs/A)	Seeding Rate (lbs/A)	Seeding Depth (inches)	% N in above ground biomass^	Rhizobium Inoculant Type
Annual medic	SA	40-100	10-40	1/4 - 1/2	1.2	A
Berseem clover	SA	60-90	9-20	1/4 - 1/2	2.6	R
Crimson clover	SA	50-60	12-20	1/4 - 1/2	2.4-3	R
Austrian peas	SA / WA	30-100	70-150	1 - 2	3-4	C
Hairy vetch	WA	60-180	20-35	1/2-3/4	4	C
Mammoth red clover	B	60-70	8-15	1/4 - 1/2	2-3	B
Sweetclover (yellow)	B	70-90	8-15	1/4 - 1/2	2-3	A
Alfalfa	P	50-150	9-25	1/4 - 1/2	3.3	A
White clover	P	60-100	5-7	1/4 - 1/2	2-4	B
Medium red clover	P	60-70	10-15	1/4 - 1/2	2-3	B
Alsike clover	P	60-70	4-10	1/4 - 1/2	2-3	B

Notes:
Life cycles: P = perennial, WA = winter annual, SA = summer annual, B = biennial
Nitrogen values vary depending on cover crop densities and date of planting
^ % Nitrogen estimates from: University of California, Sustainable Agriculture Research and Education Program. Cover Crop Resource Page and USDA Plant Data Base

Non-Legume cover crop species with associated agronomic data

Species	**Life Cycle**	**Seeding Rate (lbs/A)**	**Seeding Depth (inches)**	**% Nitrogen in above ground biomass^**
Buckwheat	SA	35-60	1/4 - 1/2	1.3
Forage turnips	SA	3-5	1/4 - 1/2	3.3 leaf, 1.6 root
Forage radish	SA	10-15	1/4 - 1/2	1.6 root
Oilseed radish	SA	25	1/4 - 1/2	3.8 leaf, 2.5 root
Mustards (White)	SA	15	1/4 - 1/2	2.8-3.5
Mustards (Oriental)	SA	10	1/4 - 1/2	2.8-3.5
Canola / Rape	SA/WA	15	1/4 - 1/2	1.3
Annual ryegrass	SA	15-25	1/4 - 1/2	1.3
Barley	SA / WA	50-100	1 - 2	1-2
Rye	SA / WA	50-100	1 - 2	1-2
Triticale	SA / WA	50-100	1 - 2	1-2
Wheat	SA / WA	50-100	1 - 2	1-2
Oats	SA	35-70	1 - 2	1-2
Sudangrass	SA	20-60	1 - 2	1.5

Notes:
Life cycles: P = perennial, WA = winter annual, SA = summer annual, B = biennial
^ % Nitrogen estimates from: *University of California Sustainable Agriculture Research and Education Program. Cover Crop Resource Page and USDA Plant Data Base*

Recycling nitrogen and reducing losses

An important benefit of cover crops is their ability to recycle nitrogen and reduce leaching losses. Wagger and Mengel (1988) reported that wheat or rye cover crops following corn generally retained 10 to 90 lbs/ac of soil nitrogen that would otherwise be available for leaching. Shipley et al. (1992) reported that 10 to 45% of the nitrogen fertilizer was retained in rye, annual ryegrass, and hairy vetch cover crops which were planted following harvest of corn. Furthermore, these three cover crops were more efficient than resident weeds at taking up nitrogen. While fall cover crops generally reduce nitrate leaching, cover crop residues can increase nitrate leaching if decomposition of cover residues is rapid and coupled with excessive rainfall or over-irrigation (Miller et al., 1994).

Fall cover crops have been used in California to improve the nitrogen supply in soil. Annual legumes seeded in October have contributed in excess of 200 lbs N/ac/yr by March in a study conducted at Davis, CA (Miller, 1990). The accumulated nitrogen is largely held in the top growth and released after plow down. Annual legumes will use residual nitrogen as well as fix nitrogen and may be an excellent early fall cover crop for the Pacific Northwest. However, most annual legumes have exhibited slow growth in cool temperatures in trials conducted in the Pacific Northwest.

Corn and potatoes are two important crops grown in the Pacific Northwest. Neither of these crops utilize large amounts of nitrogen late in development (Hammond, 1992; Thornton et al. 1997). Low utilization coupled with decomposition of postharvest residues can result in a large pool of residual nitrogen remaining in the soil. A 1993-1994 cover crop following sweet corn planted near Plymouth, WA, showed that the cover crops accumulated 29 to 125 lbs N/ac in the above-ground portion (Weinert et al., 1995). The cover crops were seeded in late August and were either allowed to over-winter or were incorporated in late fall. Spring incorporated cover crops that over-wintered accumulated between 100 and 125 lbs N/ac. Spring incorporation of the over-wintered cover crop maintained the nitrogen in the upper

1 Forage radish used to relieve soil compaction

profile, and nitrogen was released for up to 60 days after incorporation. Nitrate movement below 2 feet was reduced in the soil below over-wintering/spring plowed cover crops, compared to fallow ground and fall incorporated cover. Fall incorporated cover crops fared somewhat poorly and approximately 75 lbs N/ac escaped deep into the soil profile. Postponing fall incorporation would probably reduce decomposition and release of nitrogen into the soil. Potatoes were planted into the field at the end of the study and none of the cover crop treatments effected tuber yield or quality. Planting potatoes 2-3 weeks after incorporation ensures adequate time for the biomass to begin decomposition. Decomposition is needed to release the nitrogen and prevent difficulties with potato planting operations.

A series of fall cover crop studies conducted near George, WA evaluated growth and nitrogen capture. Results of a planting date study showed that seedings made in the first week of September produced between 0.4 to 2.2 tons dry matter/ac by mid-November (Gillespie et al., 1998). Oats provided the most biomass production and winter-peas provided the least biomass production. Unseeded plots contained 119 lbs N/ac in the top 6 feet of soil. Nitrogen capture ranged from 57 to 91 lbs N/ac in the cover crop plots. In comparison, seedings made in early October produced at most 0.13 tons dry matter/ac on the same sampling date. Nitrogen capture was negligible for the October seeded cover crops because they failed to acquire much growth beyond the 2-leaf stage and root development was minimal. A concurrent study nitrogen did not improve fall above-ground growth (Gillespie et al., 1998). The limiting factor for fall growth was not available nitrogen but rather growing degree days.

Cover crop plots at the Pullman, WA, Plant Material Center

Preliminary results of a study conducted by Brunty and Pan at the WSU Othello Agricultural Research and Extension Center showed a large accumulation of nitrogen occurring between 3 and 4 feet in bare ground in the spring (Figure 1). Fall seeded "Aroostook" cereal rye and "Breaker" triticale captured the most nitrogen. "Greenwave" mustard did not over-winter. Much of the captured nitrogen in "Greenwave" was stored in the above-ground tissues. As these tissues decomposed in the spring, the nitrogen was released into the soil profile. "Stephens" winter wheat recovered much of the residual nitrogen but not as effectively as the other crops. Sudangrass failed to develop more than 2-leaves evaluated whether surface applied nitrogen fertilizer would stimulate fall growth and overall plant vigor. Results showed that applying because the August 30 seeding date did not provide adequate growing degree days for growth. However, sudangrass has performed very well in cover crop trials that were seeded the first week of August.

Two sites were selected in central Washington for the 1995-1996 study. The first site was located near George on a sandy soil (I = 310, Water Holding Cap. 0.09"/inch). The previous crop, potatoes, was harvested a few days prior to planting the cover crop study. The second site was located at the Lind Dryland Experiment Station on a silt loam soil (I=56, Water Holding Cap. 0.23"/inch). The previous crop was barley. Sixteen cultivars were seeded at the George site on October 11, 1995 using a Hege 90 plot drill with 8-inch row spacing. Seeding rates were 80 lb/acre for the small grains, 98 lb/acre for the peas, and 18 lb/acre for the turnips. Seeding depth was 1.5-inches with the exception of the turnip which was seeded at 0.5-inch. The field was sprinkler irrigated the following day. The same 16 varieties plus 'Moro' winter wheat were seeded at Lind on October 12, 1995 using the same drill. Both sites were pre-irrigated. Each variety plot was 6'x 20' and replicated three times at each site. Growth data were collected during the fall and spring. A portion of each plot was clipped on 4/10/96 and 5/9/96 at George and Lind, respectively to estimate biomass production. *(Late Fall Seeded Cover Crops Trial, Ag Technical Note No.8 Pullman, WA)*

Variety	**% Spring Ground cover ***		**Spring biomass Produced ****	
	George	**Lind**	**George**	**Lind**
	%		Lbs/ acre	
'Stephens' Winter Wheat	81	83	316	3221
'Celia' Winter Triticale	88	82	310	4066
'Centurk' Winter Wheat	88	87	394	3190
'Common' Austrian Winter Pea	27	37	77	538
'Alpowa' Spring Wheat	86	88	437	4265
'Breaker' Winter Triticale	93	93	531	5307
'Dusty' Winter Wheat	72	75	157	1258
'Granger' Austrian Winter Pea	23	45	60	444
'Parma' Winter Triticale	87	87	439	4737
'Grey' Winter Oats	23	28	34	548

'Hoody' Winter Barley	80	80	3368	3368
'Norstar' Winter Wheat	78	83	1876	1876
'Penawawa' Spring wheat	38	65	1478	1478
'Yamhill' Winter Wheat	78	80	2837	2837
'Moro' Winter Wheat	--	88	3165	3165
LSD .05	13.4	8.8	135.2	1047.8

* Rated 4-3-96 at Lind, 4-8-96 at George

** Clipped 4-10-96 at George , 5-9-96 at Lind

Cover Crops - PMC Study - Aberdeen, Idaho

In 1992, the Aberdeen Plant Materials Center conducted a screening trial of 115 accessions of cereals, legumes, broadleaf crops and perennial grasses. An early spring planting date (March 25), late spring planting date (June 3) and an early fall planting date (September 2) were made with all accessions. A late fall, non-replicated planting (October 20) of 13 grasses and cereals and 20 legumes and broadleaf accessions was also conducted. Nineteen accessions were planted in a complete randomized block design with 4 replications. The remaining accessions were planted as single plots for observational purposes. Due to the number of accessions in the study, seeding rates were standardized with large seed accessions planted at 20 seeds per linear foot; medium sized seed at 30 seeds per linear foot; and small sized seed at 40 seeds per linear foot. Accessions that require inoculation were inoculated just prior to planting. Plots were seeded with a Tye drill with double disk openers and 10 inch row spacing. Planting depth varied from 0.25 inches to 1.5 inches depending on accession. Plots were 14 feet wide by 33 feet long. At all planting dates except for the late fall planting plots were irrigated to meet plant needs.

Stand emergence, plant height and canopy cover data were collected in addition to air-dry forage production from the spring planting dates. The early fall planting date did not include forage production data but included the other plant parameters. The late fall planting date was evaluated for stand emergence only. Following is a summary of the best performing accessions from each planting date in the replicated plots:

1992 Cover crop plots at the Aberdeen PMC

Accession	Stand Emergence (1 best, 9 worst)	Canopy cover (percent)	Weed Suppression (1 best, 9 worst)	Forage Production (tons/ac dry)
Early Spring Planting				
Civasto Turnip	1.0	94	3.5	7.27
Schuyler Barley	1.0	85	2.5	4.49
Seco Barley	1.0	86	2.3	4.37
Owens Wheat	1.0	78	2.5	4.19
Late Spring Planting				
Civasto Turnip	2.3	96	1.8	7.77
Field Corn	4.5	85	2.4	6.16
Trudan 8 Sudangrass	3.3	85	2.1	4.23
Red Proso Millet	2.5	93	1.5	4.21
Austrian Pea	3.4	90	2.0	2.97
Early Fall Planting				
Seco Barley	1.8	88	1.8	--
Civasto Turnip	3.2	80	2.8	--
Schuyler Barley	1.3	78	2.8	--
Aroostock Rye	4.5	63	5.0	--

Regreen Wheatgrass	3.3	59	4.8	--
Late Fall Planting				
Yellow Mustard	2.0	--	--	--
Tyfon Mustard	3.0	--	--	--
Brown Mustard	4.0	--	--	--
Sparta Rape	4.0	--	--	--
Forage Star Turnip	4.0	--	--	--

Accessions from the non-replicated plots that show promise for cover crops include Humas Rape, Forage Star Turnip, Tyfon Mustard, Field Corn, Sun Wheat (*Helianthus spp.*), and Crystal Barley.

Cover crop examples from other states

Researchers in Michigan have adopted a corn system that includes a 10-inch band herbicide treatment followed by two cultivations. Cover crops are over-seeded at the second cultivation of the corn crop. Several cover crop species have been successfully established using this technique, including crimson clover, mammoth red clover, annual ryegrass, hairy vetch and a 60 percent red clover / 40 percent sweet clover mixture. Timing is very important to successfully establish a cover crop by over-seeding. It is extremely important to seed when there is enough light to germinate and establish the cover crop, yet late enough so it will not compete with the corn crop for water, nutrients or light.

Cover crop mix (chickling vetch, lentils, cowpeas) no tilled into wheat stubble

Research from the Dakota Lakes Research Farm in Pierre, South Dakota in 2008 reports planting a mix of chickling vetch, lentils, and cowpeas (black-eyed peas). All three are legumes that fix atmospheric nitrogen, but they perform best at different times of the year. By October 15, this

Cotton no-tilled into rolled rye cover crop, Alabama

mix produced 2.62 tons of forage per acre, containing 3.93% nitrogen or 206 pounds per acre. Another mix of forage radish, lentils, and chickling vetch were planted after irrigated wheat harvest. By October 15, they had produced 2.42 tons of forage per acre, containing 2.77% nitrogen or 134 pounds per acre.

USDA-ARS researchers in Auburn, Alabama have successfully demonstrated growing cereal rye as a cover crop. The rye is planted after the previous crop (soybeans) was harvested and allowed to grow and then rolled with a crimper/roller which kinks the stem in multiple places and kills the plant. After being rolled the rye produced a 4 inch matt virtually eliminating any weed competition. An in row subsoiler was used to relieve any compaction and then cotton was planted with a double disk planter with residue managers attached. A challenge in Idaho is having enough growing season to get the rye tall enough so the stem will kink when rolled.

Estimating the Amount of Nitrogen (N) Scavenged by the Cover Crop

To do this, access the total yield of the cover crop and the percentage of nitrogen in the plants just before they die. To estimate yield, take cuttings from several areas in the field, dry and weigh them. Using a yardstick or metal frame of known dimensions (1 ft x 2 ft which equals 2 ft^2 works well) clip the plants at ground level within the known area. Dry them out in the sun for a few consecutive days, or use an oven at about 140 degrees F for 24 to 48 hours until they are "crunchy dry". Use the following equation to determine per-acre yield of dry matter:

$$\textbf{Yield (lbs) / acre} = \frac{\textbf{total weight for dried samples (lbs)}}{\textbf{\# square feet you sampled}} \times \frac{\textbf{43,560 sq ft}}{\textbf{1 Acre}}$$

While actually sampling is more accurate, you can estimate your yield from the height of your green manure crop and its percentage of groundcover. Use these estimators: At 100 percent ground cover and 6-inch height, most non-woody legumes will contain roughly 2,000 lbs/ A of dry matter. For each additional inch, add 150 lbs. For most small grains and other annual grasses, start with 2,000 lbs /A at 6 inches and 100 percent groundcover. Add 300 lbs for each additional inch and multiple by percentage of ground cover. A crop that is 18 inches tall and 100 % groundcover will weigh roughly:

6 inches = 2,000 lbs
12 inches = 150 lbs /inch x 12 = 1,800 lbs
Total = 3,800 lbs

If the stand is less than 100% groundcover, multiply by the % of groundcover. Keep in mind that these are rough estimates to give you a quick guide for the productivity of your green manure. To know the exact % N in your plant tissue, you should send it to a lab for analysis. Testing is always a good idea, as it can help you refine your N estimates for subsequent growing seasons. Soil testing in the spring and fall provides trend data for N residual.

The following rules of thumb may help here: Annual legumes typically have between 3.5 and 4 percent N in their aboveground parts prior to flowering (for young plants use the higher end of the range), and 3 to 3.5 % after flowering. Most cover crop grasses contain 2 to 3 percent N before flowering and 1.5 to 2.5% after flowering. Other covers such as brassicas and buckwheat, will generally be similar to, or slightly below grasses in their N content.

Total N in cover crop (lbs /A) = yield lbs/A x %N

To estimate what will be available to your crop this year, divide this quantity of N by:

- 2, if the green manure will be conventionally tilled
- 4, if it will be left on the surface in a no-till system

Example: Wheat cover crop 18 inches tall 100% cover, conventionally tilled into the soil.

6 inches = 2,000 lbs
6 inches = 300 lbs /inch x 6 = 1,800 lbs
Total = 3,800 lbs

3,800 lbs /A x 0.03 N = 114 lbs of N / 2 = 57 lbs N available for current crop year.

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