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Cover Crops for the Intermountain West

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This Technical Note provides descriptions and planting recommendations for several known cover crop species that may have applicability in Idaho. The species are divided into five functional groups: cool season grasses, cool season broadleaves, legumes, warm season broadleaves and warm season grasses.

Introduction	4
Species Descriptions	6
Cool Season Grasses	6
Barley	6
Oat	6
Rye, Cereal	7
Ryegrass, Annual (Italian)	7
Triticale	8
Wheat	8
Cool Season Broadleaf	9
Arugula	9
Beet	10
Cabbage, Ethiopian	10
Flax	11
Mustard, Oriental and White	11
Phacelia	12
Radish, Forage and Oilseed	13
Rapeseed (Canola)	13
Turnip	14
Legumes	15
Alfalfa	15
Bean, Fava (Bell)	15
Clover, Crimson	16
Clover, Red	16
Clover, White	17
Cowpea	18
Lentil	18
Medic	19
Pea, Austrian Winter	20
Pea, Spring	20
Sunn Hemp	21
Sweetclover, Yellow & White	21
Vetch, Chickling	22
Vetch, Common	23
Vetch, Hairy	23
Warm Season Broadleaf	24
Buckwheat	24
Chicory	25
Flower Mix	26
Safflower	26
Sunflower	27
Warm Season Grasses	28
Corn	28
Millet, Foxtail	28
Millet, Pearl	29
Millet, Proso	30
Sorghum, Grain	31
Sudangrass	32
Teff	33
Appendix: Seeding Information for Intermountain Cover Crop Species	34
Cool Season Grasses	34
Cool Season Broadleaf	34
Legumes	35
Warm Season Broadleaf	35
Warm Season Grasses	36



Multi-species cover crop mix. (Radish, Turnip, Sudangrass, Millet, Buckwheat, Oats, Soybean, Mustard). No Till seeded August 15th behind winter wheat stubble, grazed late fall/winter.

Introduction

A cover crop is a crop that is generally not mechanically harvested but is grown to benefit the soil and or other crops in numerous ways. Cover crops can play an important role in increasing soil health, improving soil structure and reducing the need for costly inputs such as fertilizer and mechanical tillage. Cover crops can decrease erosion and increase water infiltration and retention. They also reduce nitrogen leaching and compaction and suppress weed growth. Adding cover crops to the rotation when technically feasible increases the presence of active living roots. Active roots produce more amino polysaccharides and glomalin because mycorrhizal fungus populations increase due to a stable food supply. Polysaccharides from plants and glomalin from fungi weakly hold the microaggregates together but are consumed by bacteria, so they need to be continually reproduced in the soil to improve soil structure.

Biodiversity (growing more plants in rotation) increases the success of most agricultural systems. Diversity above ground improves biological diversity below ground. The successful use of cover crops requires proper selection of species, correct timing of seeding and proper management practices. Best results are achieved when using a variety of cover crops to increase plant species diversity (which affects the below-ground fauna). Cover crop species can be divided into five categories: cool season grasses, cool season broadleaf species, legumes, warm season broadleaf species, and warm season grasses. Selecting a suite of species, some from each of these categories, fills the above and below ground niches and provides a diverse root system where soil microbes and other organisms thrive.

Using cover crops and increasing crop rotation diversity helps restore soil health, protects against erosion and groundwater leaching, and can provide feed and cover for livestock and wildlife. One rationale for the increased use of cover crops is to provide a living, growing plant in our annual cropping system at times of the year when we typically have nothing growing. We can extend our growing season with cover crops.

Developing a seeding mix

Species should be matched to the site conditions, available irrigation, soil type and season. Producers should develop the cover crop mix based on what recourse concerns they are trying to fix. Purposes are many and include: reduced erosion, increased organic matter, capture and recycle or redistribute nutrients, promote nitrogen fixation, increase biodiversity, suppress weeds and reduce soil compaction. Mixes can be developed based on cool season early planting to warm season mixes planted during summer months. Mixes can be planned to winter kill or survive winter conditions. One to several species should be selected from each of the plant categories and the percentage of the total mixture for each species should be determined. General multi-species mixes are suggested to be drilled at PLS rates of 30-40 lbs /acre. When rates exceed 40 lbs per acre, cost usually becomes excessive, unless specific purposes are desired. Seed size can lower or raise this seeding rate, based on the number of seeds per pound. The NRCS specification sheet for cover crops located in the eFOTG has a spreadsheet to help producers and planners develop seed mixes.

The seeding rates provided in this document reflect the full stand seeding rate, in other words, the seeding rate if you were to plant a single species. For a mixture, the desired percentage is

multiplied by the full stand seeding rate to determine the appropriate seeding rate for each component of the mixture (Table 1).

Some species may fall under state restrictions. It is the end user's responsibility to ensure that all rules and regulations are observed.

Table 1. Example of an 8 way cool season cover crop mixture.

	Full Stand	Multi Species Mix
	Seeding	Seeding
Species	Rate	Rate (PLS)
	<i>lbs/ac</i>	<i>lbs/ac</i>
Oat	100	10
Triticale	100	10
Phacelia	10	1
Radish	8	1
Hairy Vetch	30	6.5
Crimson Clover	15	1.5
Winter Pea	100	10
Turnip	4	.5
	Total:	40.5

Table 2. Example of a 10 way warm season cover crop mixture.

	Full Stand	Multi Species Mix
	Seeding	Seeding
Species	Rate	Rate (PLS)
	<i>Lbs/ac</i>	<i>Lbs/ac</i>
Oat (cool season)	100	10
Proso Millet	20	3
Radish (cool season)	15	1
Hairy Vetch (cool season)	60	6
Buckwheat	50	1
Winter Pea (cool season)	100	10
Turnip (cool season)	5	.5
Sunflower	4	1
Grazing Corn	40	4
	Total:	37.5

Cool Season Grasses

Barley

Hordeum vulgare



Barley is a cool season annual cereal grain that may be used as a cover crop or as a component of a cover crop mix to prevent erosion, suppress weeds, scavenge excess soil nutrients and add organic matter. It can also be used as a soil-protective companion crop for sugar beet seedlings. In grain production fields, barley produces about 4.8 tons/ac of straw, chaff, and uncut stubble. It is more salt tolerant than other small grains. Both spring and winter varieties are

available but open, cold winters with large temperature fluctuations will result in winterkill and/or root damage from frost heaving. Typical rooting depth of the fibrous roots is 2-3 feet but can reach 6-7 feet in deep soils. Barley works well in mixtures with other grasses or legumes. Barley produces alkaloids that have been shown to inhibit germination and growth of white mustard. These alkaloids also protect barley plants from fungus, armyworm larvae, bacteria and aphids. Barley establishes readily in prepared seedbeds but can also be successfully no-tilled. If broadcasting, prepare the seedbed with at least one field cultivation and increase the seeding rate by 25%. The full seeding rate for cover crop applications is 50-100 lbs/ac with a seeding depth of 1.0-2.0 inches. There are approximately 13,000 seeds/lb.

Oat

Avena sativa

Oats are a cool season annual cereal grain that may be used as a cover crop or as a component of a cover crop mix to prevent erosion, suppress weeds, scavenge excess nutrients and add organic matter. Oats winterkill when air temperatures reach approximately 18° F so it is best suited for early spring planting or late summer cover crop mixes. The biomass from oats provides a mellow mulch for no-till crops. Oats thrive under cool, moist conditions on well-drained soils and can reach heights in excess of four feet. Oats do not fare well in hot, dry weather. Oats work well in cover crops mixes with clover, peas, vetch and other small grains and can produce as much as 8,000 lbs/ac biomass from spring seeded stands and 2,000-4,000 lbs/ac from late summer seedings. Oat roots and residue have allelopathic compounds that can hinder germination and growth of subsequent crops such as lettuce, timothy, wheat and peas. Minimize these effects by waiting three weeks after killing the oats before seeding a susceptible crop. The



full seeding rate for cover crop applications is 50-100 lbs/ac and 0.75-1.5 inch seeding depth. There are approximately 15,000 seeds/lb.

Rye, Cereal

Secale cereal



Cereal rye is a highly popular large-statured cool season annual grass with excellent production values. It is widely used as a cover crop for several factors: high biomass yield, weed suppression, nutrient scavenging and inexpensive seed. It can be seeded both before and after main crop harvest, and it works well in mixtures. Caution: cereal rye can be very invasive in areas that grow small grains and in disturbed areas and is generally not

recommended in the Aberdeen PMC service area. Cereal rye is used extensively in cover crop mixes in other parts of the United States where winter wheat is not in rotation and is one of the best cool-season, over wintering cereal grain cover crops for taking up excess soil nitrogen and is often planted in cover crop mixes with legumes. Many organic vegetable growers use cereal rye for its fast growth and high carbon content. There are approximately 15,000 seeds/lb. Full seeding rate is approximately 60-120 lbs/ac with a planting depth of 1.0-1.5 inches.

Ryegrass, Annual (Italian)

Lolium multiflorum

Annual ryegrass is a quick-growing cool season bunch grass used for erosion control, weed suppression, soil structure improvement and to add organic matter. It usually winterkills, but if it overwinters, it will grow quickly and produce seed in late spring. It can be a serious problem in oat and wheat crops if allowed to set seed and has been shown to develop herbicide resistance.

Ryegrass prefers fertile, well-drained loam soils but can establish on many soil types. It will outperform small grains on wet soils. Rapid aboveground growth can produce as much as 9,000 lbs/ac from a spring seeding. Annual ryegrass can be mixed with legumes or small grains but will dominate the mixture unless seeded at low rates or is mowed regularly. Spring seeding is recommended for production of large amounts of biomass or it could be seeded in late summer with a mixture of legumes to provide overwinter protection for the legume, but must be established at least 40 days before the first killing frost. The full seeding rate for cover crop applications is 10-20 lbs/ac and 0.25-1.0 inch seeding depth. If using as a component of a cover crop mix, limit the amount of annual ryegrass to no more than half the full rate (7-15 lbs/ac)



because it is extremely competitive. Annual ryegrass can be over seeded into corn at the last cultivation but the seeding rate should be increased by 30 percent. There are approximately 190,000 seeds/lb.

Triticale

x Triticosecale

Triticale is a cross between wheat (*Triticum*) and rye (*Secale*) that combines the grain quality, productivity and disease resistance of wheat with the vigor and hardiness of rye. It does not have invasive characteristics as cereal rye does. Most triticale is sold as feed grain. There is growing interest in using triticale as a double-cropped winter forage crop following corn silage to increase total forage available and increase total crop phosphorous removal. Double cropping with triticale is helpful in mitigating the effects of phosphorous applied in manures and compost. Triticale can also be used in cover crop mixes similar to other small grains and can be mixed with annual legumes, rye grass and other small grains. The full seeding rate for triticale is 60-120 lbs/ac and 0.75-1.5 inch seeding depth. Planting dates for fall seeded triticale are late August to mid-September for adequate growth before winter. Spring varieties of triticale are also available. If grazing is a purpose, triticale, like other small grains, will develop seed heads that are not very palatable. One option is to plant winter grains in the spring so that they do not produce seed heads, but remain vegetative the whole season. There are approximately 13,500 seeds/lb.

Wheat

Triticum aestivum

Wheat is a cool season annual grass typically grown as a cash grain. As a cover crop, wheat can be used to prevent erosion, suppress weeds, uptake excess soil nutrients and add organic matter. Although winter wheat is typically planted in the fall, it can be spring planted to meet cover crop objectives. Spring planting of winter wheat may prevent seed formation if plants are not subjected to freezing temperatures during the seedling stage. Spring wheat planted in early spring may also be used as a cover crop with or without a legume. Wheat can also be used as a soil-protective companion crop for sugar beet seedlings when winter wheat is planted in the fall and then sugar beets are planted in the spring into living winter wheat which is then killed with herbicide following sugar beet emergence. Wheat prefers well-drained soils of medium texture and moderate fertility. It tolerates poorly drained, heavier soils better than barley or oats, but flooding and standing water can easily drown wheat. It can be mixed with annual legumes, ryegrass and other small grains in a cover crop mix. Dryland winter wheat production fields can produce about 4.8 tons/ac of straw, chaff, and uncut stubble. The full seeding rate for wheat cover crop applications is 60-120 lbs/ac and seeding depth of 1.0-2.0 inches in late August to mid-September for adequate growth before winter. A rule of thumb in



southern Idaho is that winter wheat should be planted no later than October 1st to provide adequate cover for wind erosion control. There are approximately 11,400 seeds/lb.

Cool Season Broadleaf Plants

Arugula

Eruca vesidaria ssp. sativa

Arugula is a fall-seeded, overwintering brassica that is useful for suppressing weeds and soil borne pests, minimizing surface compaction and scavenging nutrients. It produces less ground cover but may have more biofumigation potential than turnips or rape. Glucosinolates are compounds found in brassicas that are responsible for suppression of soil borne pests. Arugula has been



studied along with rapeseed and mustard as green manure alternatives to fumigation for control of Columbia root-knot nematode in potato systems in the Pacific Northwest. However, green manures cannot be recommended alone for adequate control of the nematode. Because the fumigant chemicals are only produced when individual plant cells are ruptured, biofumigation requires that plants are mowed before seed set and incorporated and soil rolled to seal the surface immediately. Allow 10 days after incorporation and soil sealing before planting next field crop. Brassicas can suppress small seeded annual weeds such as pigweed, shepherds purse, kochia and hairy nightshade but must be supplemented with herbicides or cultivation to avoid crop losses from the crop following the cover crop. To maximize biomass production and nutrient scavenging in the fall, brassicas must be planted earlier than winter cereal cover crops in most regions, making them more difficult to fit into grain production rotations. The full seeding rate for arugula is 4-8 lbs/ac and 0.25-0.50 inch seeding depth. There are approximately 280,000 seeds/lb.

Beet

Beta vulgaris

Beets were historically used as livestock root fodder in many parts of the world, but with technology development of small grain production and storage and improved transportation beginning in the early 1900's, beets for livestock fodder dramatically declined. As economic conditions drive up the cost of feed grains, there is some renewed interest in beets for livestock fodder. There is limited information available regarding the use of beets as cover crop species, but beets are very similar to turnips and may provide similar benefits in reducing soil compaction and improved soil water infiltration. Beets may also suppress weeds and scavenge excess nitrogen. Fodder beets are usually planted in spring alone and the roots harvested for fodder, but could be planted with other cover crop plants to provide summer and fall forage for livestock as well as a component of cover crop mix planted in August. Fodder beets are injured by heavy frosts and will most likely winterkill at temperatures around 25°F. Beets may be seeded with a grain drill and 0.75-1.5 inch seeding depth. The full seeding rate is 1-2 lbs/ac. There are approximately 10,000 seeds/lb.



Cabbage, Ethiopian

Brassica carinata

Ethiopian cabbage is a tall-statured member of the mustard family, usually 3-4 feet tall but can reach heights of 6 feet. The foliage is light green color with purplish veins and flowers are usually light yellow in color. It stays upright after ripening and residue may tend to break down slower than other mustards. Ethiopian cabbage germinates about 5-6 days after planting, and flowers in approximately 160 days. It winterkills at 32°F when in early growth. Information on its use as a cover crop species is limited. Assume cover crop uses, seeding rate and seeding depth approximately same as other mustard species. There are approximately 180,000 seeds/lb. Full seeding rate is 8-16 lbs/ac at a depth of 0.25-0.5 inches.

Flax

Linum usitatissimum



Flax is a slender, erect annual plant growing 18-36 inches tall with blue, white, pink, or violet colored flowers (not to be confused with perennial and Lewis flax used in conservation plantings) and a short tap root with fibrous branches. Plants mature in 90-100 days with flowering occurring 45-60 days after planting and another 30-40 days to seed maturity. Flax is grown commercially for linseed oil extracted from the seed and

for linseed meal which is used as a livestock feed supplement. States that have the largest flax production acreages are North Dakota, South Dakota and Minnesota. It is not well-suited to areas that have less than 16 inches annual precipitation. Flax brings diversity to crop rotations with wheat and other small grains. Flax leaves, which are small, fall gradually when seed is ripening, allowing an increasing amount of light to reach under seeded crops. Spring and early fall frosts generally do not damage flax plants that have passed the two-leafed stage. Young plants can typically withstand temperatures as low as 20°F for a short time. In the Midwest, flax has been planted in place of spring grains when springtime flooding conditions have prevented planting grain at the optimum time. Flax has also been planted in strips in grain fields to catch snow. It can be used as a component of cover crop mixes in both spring and summer plantings. It is best adapted to fertile, fine-textured soils but does not establish well on coarse-textured soils or under wet conditions. The full seeding rate for annual flax is 30-50 lbs/ac and 0.25-0.50 inch seeding depth. There are approximately 80,000 seeds/lb.

Mustard, Oriental and White

Brassica juncea, *B. hirta*, *Sinapis alba*

Mustards are commonly used as green manure crops to suppress weeds, soil borne diseases and nematodes, and to improve soil quality. Plants are annual, sprout in 3-5 days, grow quickly (60-90 days) and can grow 3-5 feet tall with bright yellow colored flowers and a deep taproot with a fibrous near-surface root system. When used as green manure, mustards can suppress some potato diseases including verticillium and common root rot and suppress Columbia root-knot nematodes. Glucosinolates are compounds found in brassicas that are responsible for suppression of soilborne pests. Mustard has been studied along with rapeseed and arugula as green manure alternatives to fumigation for control of Columbia root-knot nematode in potato systems in the Pacific Northwest. However, green manures cannot



be recommended alone for adequate control of the nematode. Biofumigation requires that plants are mowed before seed set and incorporated and soil rolled to seal the surface immediately as the fumigant chemicals are only produced when individual plant cells are ruptured. Allow 10 days after incorporation and soil sealing before planting next field crop. Mustards for green manure are typically planted in August following small grains. Mustards can withstand temperatures into the low 20s°F and can also become weedy if allowed to mature to seed ripeness. In very mild winters when mustards are not winterkilled, green peach aphids may overwinter on mustards. To avoid overwintering aphids, kill the cover crop before spring warmup. The full seeding rate for mustard is 8-16 lbs/ac and 0.25-0.50 inch seeding depth. There are approximately 180,000 seeds/lb.

Phacelia

Phacelia tanacetifolia

Phacelia is an annual broadleaf plant, native to the southwest region of the United States and Mexico and has been used in Europe as a cover crop and as bee forage. It is becoming more commonly used in California vineyards. It ranges in height from 6-47 inches with fern-like foliage and the flowers are in flat-topped clusters and are mostly purple colored or occasionally white. Spring and summer planted phacelia flowers about 6-8 weeks following germination and flowering continues for another 6-8 weeks. It is highly attractive to honeybees, bumblebees and syrphid flies. Syrphid fly larvae are voracious feeders on aphids and young caterpillars. Phacelia may be suitable as a winter-



killed cover crop when a heavy crop residue is not needed in the spring. Research in other regions shows it has potential to produce abundant biomass and does a good job of scavenging excess nitrogen. Phacelia winterkills at about 18°F and residue breaks down rapidly. It is best planted when soil temperatures range between 37-68°F. When used as a fall cover crop, it needs to be planted as early as possible in the fall. There is no published information on forage value, and a major drawback to its use is the high cost of seed. It may be best to broadcast the small seed at 11-18 lbs/ac and then pack the field so that seed is not buried more than 0.125-0.5 inches deep. If drilling seed, plant 7-12 lbs/ac. There are approximately 225,000 seeds/lb.

Radish, Forage and Oilseed

Raphanus sativus var. *niger* and *R. sativus* var. *oleiformis*



Radish has long been used for cover crops and livestock forage. Forage radish (daikon or Japanese radish) has a very large taproot. Oilseed radish, originally developed for oil production, is similar to forage radish but its taproot is stubbier and more branched and tends to be somewhat more winter hardy than the forage radish. The fine root hairs along the taproot have been documented to reach as far as six feet deep in the soil. Radish is especially useful in suppressing weeds, breaking up shallow layers of compacted soils which promote deeper rooting by subsequent crops and increases water

infiltration. Above ground biomass from August planting can approach 8,000-10,000 lbs/ac (dry weight) after two9 months of growth. The residue from radish decomposes rapidly resulting in less mobilization of nitrogen and prepares a relatively clean seedbed for no-till planting. During warm spells in winter, rotting radish residues produce a strong, rotten egg-like odor. Radish generally tolerate cold temperatures to around 10 °F but August plantings have stayed partially green well into December and January at the Aberdeen, Idaho Plant Materials Center when day time temperatures are usually below 25°F. To maximize root growth, drilling in rows is preferred. Broadcasting radish at higher seeding rates, limits root growth because plants tend to be spaced closer together but broadcasting creates a dense canopy for suppressing weeds. The full seeding rate for radish is 6-8 lbs/ac and 0.25-0.75 inch seeding depth. There are approximately 50,000 seeds/lb.

Rapeseed (Canola) *Brassica napus* (annual or spring type), *Brassica rapa* (winter type or biennial)

Rapeseed is a large, stemmy winter or spring annual (sometimes biennial) that can grow 3-5 feet tall with bright yellow colored flowers and a deep taproot with a fibrous near-surface root system. Rapeseed produces large amounts of biomass, suppresses weeds, and the root system can help loosen plow pans and improve soil tilth. It is commercially grown for its oil and meal. In cover crop applications it also scavenges excess nitrogen. The minimum



soil temperature for planting is 45°F and maximum soil temperature for planting is 85°F. Winter hardiness of the winter types are excellent if plants reach a rosette size of 6-8 leaves before the

first killing frost but temperatures below 10°F will winterkill the most hardy winter types. Glucosinolates are compounds found in brassicas that are responsible for suppression of soil borne pests. Rapeseed has been studied along with mustard and arugula as green manure alternatives to fumigation for control of Columbia root-knot nematode in potato systems in the Pacific Northwest. However, green manures cannot be recommended alone for adequate control of the nematode. Biofumigation requires that plants are mowed/shredded before seed set and incorporated and soil rolled to seal the surface immediately. This is because the fumigant chemicals are only produced when individual plant cells are ruptured. Allow ten days after incorporation and soil sealing before planting next field crop. If grazing rapeseed, choose varieties that have low glucosinolates. The full seeding rate for rapeseed is 5-16 lbs/ac and 0.25-0.50 inch seeding depth. There are approximately 135,000 seeds/lb.

Turnip

Brassica rapa var. *rapa* and *Brassica napus*

Turnips are used for both human and livestock consumption. If used for livestock forage, animals should be observed frequently as choking on the root is possible, especially if animals are not accustomed to turnips. However, in three years of Idaho NRCS use of cover crops no incidents of choking have been reported. Turnips can reduce soil compaction and improve soil water infiltration but usually do not produce as much biomass as other brassicas. Turnips can also suppress weeds and scavenge excess nitrogen. Turnips can be spring planted alone or with other cover crop plants to provide summer and fall forage for livestock as well as a component of cover crop mix planted in August. Forage type turnips produce abundant top growth compared to purple top varieties. Cold temperature hardiness varies among varieties, but most winterkill at temperatures around 10 °F. The full seeding rate for turnip is 3-5 lbs/ac and 0.25-0.50 inch seeding depth. Turnip may also be broadcast seeded but seeding rate should be doubled. There are approximately 215,000 seeds/lb. (hunter hybrid 150,000 seeds/lb; Winfred hybrid 170,000 seeds/lb).



Legumes

In most situations legumes require inoculation with a specific strain of *Rhizobium* for nitrogen fixation. See Idaho Technical Note 26 for further information. Hairy vetch, winter peas and sweet clover are examples of legumes that generally overwinter in Idaho but are not highly productive during the year (fall) of establishment, most of their production and/or function usually occurs during the second growing season.

Alfalfa

Medicago sativa

Alfalfa is the most widely grown perennial forage in the Intermountain West. The primary uses are for hay, green chop, haylage and occasionally green manure. Many growers who specialize in alfalfa forage production have a six year rotation in alfalfa. In the Midwestern United States, 125-175 pounds of nitrogen is produced by 3-5 year old stands when incorporated back into the soil. There are many producers in the west however, who do not incorporate the plant matter but spray it out to terminate the crop and then no till directly into the dead residue. Although established stands have the ability to produce substantial amounts of nitrogen to subsequent crops, alfalfa can be impractical for producers who do not feed or sell forage for livestock production. Dormant alfalfa varieties are commonly planted to withstand cold winter temperatures for perennial production. Non-dormant alfalfa varieties are well suited to annual cropping systems in northern areas of Idaho, but would need to be spring planted to maximize biomass yield and nitrogen availability. Alfalfa may grow slowly compared to annual legumes in cover crop mixes. An annual variety, 'Nitro' released in Minnesota was found to produce approximately 100 pounds of nitrogen per acre in a Canadian study compared to dormant varieties which produced about 35 pounds of nitrogen per acre from a spring planting. Alfalfa can be planted in the spring or summer as a component of a cover crop mix or as green manure but needs to be well established by the first hard frosts in the fall (approximately six weeks growth) to survive winter temperatures. The full seeding rate for alfalfa is 10-20 lbs/ac and 0.25-0.50 inch seeding depth. Inoculation with *Sinorhizobium meliloti* or *Rhizobium mongolense* is necessary for plants to fix nitrogen. There are approximately 227,000 seeds/lb.

Bean, Fava (Bell)

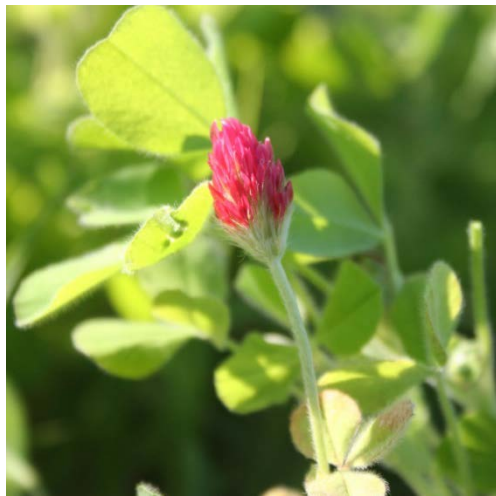
Vicia faba

Fava bean is actually a vetch. It is an erect leafy annual legume that can grow 2-6 feet tall. One or more thick, unbranched stems grow from the base of the plant and compound leaves are composed of 2-6 large fleshy leaflets that do not have tendrils. Fava bean has a taproot that is 1-3 feet long. White-colored flowers with black or dark-colored markings occur alone or in groups. Large, flat, oblong seeds develop in pods. Fava beans winter-kill at 10-15°F and do not tolerate heat well. Fava beans can be grown on clay to loam soils with pH ranging from 4.5-8.3 (low pH may delay development of root nodules for nitrogen fixation), and a variety of drainage conditions. It will not tolerate extended wet soils and drought, or where temperatures fluctuate rapidly. In our region, use of fava bean may be very limited to spring cover crop applications.

In areas where minimum annual temperatures are above 15°F, small-seeded fava bean cultivars can be planted in the fall as a winter annual and can produce 2-4 tons/ac dry biomass and 83-202 lbs/ac nitrogen. Seeding rates are 80-200 lbs/ac for small seeded types 0.75-2.0 inches deep and 150-300 lbs/ac for large seeded types and 2-4 inches deep. Most seeds are large and will have trouble flowing through drills. Check seed size before planting. Inoculation with *Rhizobium leguminosarum viciae* is necessary for plants to fix nitrogen. There are approximately 2,500-3,000 seeds/lb.

Clover, Crimson

Trifolium incarnatum



Crimson clover is an annual legume used as forage/hay, in wildlife food plots, as pollinator (bumble bee) food, in cover crops and green manure applications. Plants are densely hairy with a rosette of upright, usually unbranched stems 1-3 feet tall with a central taproot and many fibrous roots. The cylindrical or conic flower heads are at the ends of the stems and are bright scarlet or occasionally white-colored. In more temperate regions of the Pacific Northwest it can be planted as a winter legume. In colder regions it is best suited as a summer legume. (Note: in an irrigated trial at Aberdeen PMC, the variety 'Dixie' overwintered from an August

planting). Crimson clover requires approximately 25 inches or more of annual precipitation and is best adapted to well-drained, loamy soils and will also grow on sandy to clay soils with pH 5.5-7.0. It can be mixed with cereal grains, vetches, other clovers and grasses for cover crop applications. It can produce 1-2.5 tons/ac dry matter and add 70-150 lbs/ac nitrogen back to the soil if allowed to mature to the bloom stage before being killed. The full seeding rate is 15- 20 lbs/ac and 0.25-0.50 inch seeding depth. If planted for forage, bloat is not a great hazard but it is usually planted with a grass to prevent bloat problems. Inoculation with *Rhizobium leguminosarum trifolii* is necessary for plants to fix nitrogen. There are approximately 150,000 seeds/lb.

Clover, Red

Trifolium pratense

Red clover is a biennial or short-lived perennial legume that is the most widely grown of all the true clovers and is the most important legume hay crop grown in the northeastern United States. Other uses include pasture, silage, pollinator food, and soil health improvement. It grows 18-30 inches tall with 4-6 branches per stem. The taproot disintegrates in the second year of establishment and plants that survive develop secondary, extensively branched roots. Flowers are borne in compact clusters at the tip of



branches and are usually rose-pink in color. Red clover grows best on well-drained loamy soils and pH > 6.0 and grows well wherever corn grows. It requires at least 25 inches annual precipitation. Mammoth (single-cut) red clover is generally recommended for areas with a short growing season. As a cover crop, it is used primarily as a legume green manure. It can be mixed with small grains, other legumes, grasses and corn for cover crop applications. It can produce up to 8,000 lbs/ac dry matter and 70-150 lbs/ac nitrogen. It can be planted in early August for an overwinter cover crop. The full seeding rate is 4-10 lbs/ac and 0.13-0.50 inch seeding depth. If planted in a mix for forage, limit red clover to 25% to prevent livestock bloat. Inoculation with *Rhizobium leguminosarum trifolii* is necessary for plants to fix nitrogen. There are approximately 272,000 seeds/lb.

Clover, White (Dutch White, New Zealand White, Ladino)

Trifolium repens



White clover is an introduced perennial legume generally with a prostrate, stoloniferous growth form. Leaves are composed of three leaflets and leaves and roots develop along stolons at the nodes. Flowers are usually white colored but may have a pink hue. It is highly palatable and nutritious forage for all classes of livestock and wildlife and is commonly planted with orchardgrass, ryegrass, brome, and tall fescue. White clover is usually not harvested for hay because it is low growing. Many wildlife and bird species utilize the forage and seeds of white clover and honeybees and other insects cross-pollinate the flowers as they collect nectar and pollen.

White clover is best adapted to clay and silt soils in humid and irrigated areas (18 inches annual precipitation for dryland) and seldom roots deeper than two feet which makes it adapted to shallow soils when adequate moisture is available. Cultivars are grouped by size into three groups. The lowest growing type ('Wild White'), are best for heavy traffic like found in orchards and for grazing. Intermediate sizes ('Dutch White', 'New Zealand White', 'Louisiana S-1') flower earlier and more profusely and are more heat-tolerant and mostly bred for forage. The large ('Ladino') types produce the most nitrogen per acre of any white clovers and are valued for forage quality especially on poorly drained soils. A healthy stand of white clover can produce 80-130 lbs/ac nitrogen when killed the year after establishment. It could be over-seeded in early spring into standing grains or into corn in early summer and will establish under the primary crop, growing slowly while shaded and then growing more rapidly when the cash crop is harvested and more light is available to the clover. The full seeding rate for white clover is 4-8 lbs/ac and 0.13-0.25 inches deep. If planted for forage, bloat is a hazard and should be planted with a grass to prevent bloat problems. Inoculation with *Rhizobium leguminosarum trifolii* is necessary for plants to fix nitrogen. There are approximately 800,000 seeds/lbs.

Cowpea

Vigna unguiculata

Cowpea (black eyed pea) is a warm season annual legume with a wide range of growth habits from prostrate, to short and bushy to tall and vine-like with a strong taproot. It is commonly cultivated for human consumption and is also used as forage, hay and silage and in cover crop applications in the southern United States and throughout the tropics and subtropics. Depending on variety, it may grow 2-3 feet tall. Leaves are trifoliate, egg-shaped and hairless, approximately four inches long and three inches wide. White to purple colored flowers are borne in multiple racemes on 8-20 inch flower stalks that arise from the leaf axil and floral nectaries attract insects, although cowpea is primarily self-pollinating. Some types are indeterminate flowering and others are determinate. Cowpea performs best on well-drained sandy loam or sandy soil where pH ranges from 5.5-6.5. Daytime temperatures of 80°F and consistent soil temperatures of at least 65°F are optimum for germination and growth of cowpea. In areas with warm enough conditions, a cowpea cover crop can produce 2,500-4,500 lbs/ac dry matter and provide 100-150 lbs/ ac of nitrogen to a subsequent crop. It may have limited application in our region as a mid-summer cover or green manure crop because of the warm soil temperature requirements. For forage or cover crop applications cowpea can be seeded in rows or broadcast. Recommended seeding rates range from 18-22 lbs/ac for viney, indeterminate types and 40-50 lbs/ac for large seeded, determinate types. Recommended seeding depth is 0.5-1.5 inches. Inoculation with *Rhizobium leguminosarum viciae* is necessary for plants to fix nitrogen. There are approximately 3,500 seeds/lb.



Lentil

Lens culinaris



Lentil may have been one of the first agricultural crops grown for human consumption. It grows well in areas with limited precipitation (10-12 inches annual precipitation). Lentil is an excellent supplement to cereal grain diets for both humans and livestock and can be used in green manure and cover crop applications. Plants are slender, semi-erect annual legumes with compound leaves and a tendril at the tip. Plants range from 12-20 inches tall and may have a single stem (high plant density) or multiple branches (low plant density) depending on plant density. Flowering begins on the lowest branches gradually moving up the stem and flower color can be white, lilac, or pale blue and are self-pollinated. At maturity plants tend to lodge because of their weak stems. Seed must

be inoculated with *Rhizobium* in order to fix nitrogen. Lentil for crop production is planted in late April to May. Later planting dates produce shorter plants and lower seed yields. Lentil could be planted in late summer/early fall cover crop or green manure applications but will winterkill. Winter types of lentils also are available. Winter hardiness can vary with winter severity but can be comparable or better than winter peas. Lentil is adapted to all soil types that are well-drained and will not tolerate flooded or waterlogged soils and do not compete well with weeds. There can be large variation in seed size so planting with a drill is recommended and care must be taken to calibrate the drill properly. Seeding rates vary depending on seed size, but a target of 30-80 lbs/ac is the full seeding rate and 1.0-2.0 inch seeding depth. There are approximately 15,000 seeds/lb. Inoculate with *Rhizobium leguminosarum viciae*.

Medic

Medicago spp.

Medic is closely related to and resembles alfalfa during the establishment year. There are 35 known medic species that are annual and black medic (*M. lupulina*) is perennial. The annual species are generally adapted to dry conditions, prefer pH >6.0 and lack the ability to overwinter in northern regions and flower, set seed and die within one growing season (60-100 days). Some species are prostrate in growth while others are more upright and reach heights of 14-16 inches. Spring-planted medic can produce dry matter yields similar to or greater than alfalfa by July. Under favorable conditions, annual medic can produce more than 100 lbs/ac nitrogen while forming a thick ground cover but do not tend to suppress weeds when intercropped with corn. However, annual medics seeded into wheat stubble reduced weed numbers and growth of spring annuals prior to no-till corn planting the following spring. Black medic is used in rotation with grains in the Northern Plains. Medic can also provide good grazing but solid stands can cause bloat in cattle. Black medic has a high percentage of hard seed that can be beneficial or negative in terms of seed banking in the soil. Medic is ideal for reseeding systems in orchards or vineyards, but could become a weed problem in some cash crop rotations. The full seeding rate for black medic is 10-20 lbs/ac (TN57) 8-10 lbs/ac and 12-20 lbs/ac for annual medic (SARE) and 0.25-0.75 inches deep. If planted for forage, bloat is a hazard and medic should be planted with a grass to prevent bloat problems. Inoculation with *Sinorhizobium medicae* is necessary for plants to fix nitrogen. There are approximately 230,000 seeds/lb.

Pea, Austrian Winter

Pisium sativum

Austrian winter peas are cool season annual legumes that produce abundant vines and contribute to short term soil nitrogen. They grow rapidly during cool, moist weather and can withstand temperatures as low as 10°F with minor injury. Vines can grow up to nine feet long. They will survive in areas with snow cover throughout the. They are sensitive to hot temperatures especially with high humidity. Austrian winter peas can produce more than 5,000 lbs/ac dry matter when planted in spring and in areas in Idaho where they are fall planted, can produce 6,000-8,000 lbs/ac dry matter and can produce 90-150 lbs nitrogen per acre. Their quick-growing nature helps to outcompete weeds and when grown with small grains for forage, slightly improve yield and significantly boost protein and relative feed value of small grain hay. Lodging can be a problem when planted alone and at low seeding rates. The succulent stems break down easily. The purple and white-colored blossoms provide early and extended source of nectar for honeybees. Austrian winter peas can be planted in spring or late summer/fall and in combination with other cover crop species. They prefer well drained clay or loam soils but will also grow on sandy soils. The full seeding rate for Austrian winter peas is 30-100 lbs/ac and 1.5-3.0 inch seeding depth. Inoculation with *Rhizobium leguminosarum viciae* is necessary for plants to fix nitrogen. There are approximately 3,800 seeds/lb.



Pea, Spring

Pisum sativum

Spring peas are cool season annual legumes that produce abundant vines and contribute to short term soil nitrogen. Vines can grow up to nine feet long. The succulent stems break down easily. They grow rapidly during cool, moist weather in the spring and mature in 60-150 days. They are sensitive to hot temperatures especially with high humidity. Their quick growing nature helps to out compete weeds and when grown with small grains for forage, slightly improve yield and significantly boost protein and relative feed value of small grain hay. Lodging can be a problem when planted alone and at low seeding rates. The purple, pink or white colored blossoms provide early and extended source of nectar for honeybees. Spring peas can be planted in spring or late summer/fall and in combination with other cover crop species but will definitely winterkill. They prefer well drained clay or loam soils but will also grow on sandy soils. The full seeding rate for spring pea ranges from 30 to as much as 225 lbs/ac and 1.5-3.0 inch seeding depth. Inoculation with *Rhizobium leguminosarum viciae* is necessary for plants to fix nitrogen. There are approximately 2,000 seeds/lb.

Sunn Hemp

Crotalaria juncea



Sunn hemp is a shrubby, herbaceous, sub-tropical annual legume that grows three to nine feet tall. It is grown mainly in India, Brazil, and West Pakistan for its fiber. It is also used as forage for goats and sheep and as a cover crop/green manure. It has a long taproot with vigorous lateral roots and thick, ribbed, pubescent stem 0.5-2 inches in diameter. Leaves are trifoliate, arranged in a spiral around the stem. Yellow colored flowers are showy and butterfly-shaped. The major sunn hemp

growing areas have high humidity, an average temperature of 70-85°F and growing season rainfall of seven to eight inches. It is photoperiod-sensitive and flowering occurs in response to short days. It is adapted to a wide range of soils and is best-suited for sandy soils that are well drained and pH 5.0-7.5. It has low to moderate tolerance to saline soils and is very sensitive to frost. A sunn hemp adaptation trial was conducted at the Aberdeen PMC in 2009. The field was planted on June 25 and emergence occurred July 6. At 60 days of growth, plants were 2.5-3 inches tall. At 90 days after planting, plant height averaged 41 inches tall and dry matter forage yield averaged 1,788 lbs/ac with very few plants producing flowers. In areas where sunn hemp is better suited, it can produce more than 5,000 lbs/ac dry matter and 120 lbs/ac nitrogen in 9-12 weeks. The full seeding rate for Sunn Hemp is 25-50 lbs/ac and 1.0 inch seeding depth. Inoculate with *Rhizobium leguminosarum viciae* for plants to fix nitrogen. There are approximately 15,000 seeds/lb.

Sweetclover, Yellow & White

Melilotus officinalis and *M. alba*

Sweet clover is a biennial legume that can grow to five feet tall with yellow or white flowers. Yellow sweet clover (*M. officinalis*) is reported to be shorter growing, more widely branched, finer stemmed, more drought tolerant and easier to establish than white sweet clover (*M. alba*). Prior to World War II and the advent and availability of modern fertilizers, these clovers were important green manure crops. They are currently used as livestock feed/forage (can cause bloat and bleeding disease in ruminants), in wildlife habitat plantings, erosion control and pollinator plantings and are the most drought tolerant cover crop legumes, able to establish in areas receiving as little as nine inches annual precipitation. These clovers can produce up to 24 inches of vegetative growth and 2.5 tons/ac dry matter in the establishment year and 3.75-4.5



tons/ac dry matter the second growing season. Sweetclover can produce up to 200 lbs/ac nitrogen on soils with good fertility and adequate soil moisture. Taproots with extensive fibrous branches can penetrate the soil to depths of five feet helping build soil structure and reducing soil compaction. These clovers can be planted anytime of the year and can be mixed with other cover crop species but allow for six weeks of growth prior to the first fall freeze if planting in the fall. The full seeding rate is 4-10 lbs/ac and 0.50-1.5 inches deep. If planted for forage, bloat is a hazard and should be planted with a grass to prevent bloat problems. Sweetclover can be inoculated with *Sinorhizobium meliloti* or *Rhizobium mongolense* for plants to fix nitrogen. Its ability to establish in disturbed areas and to invade adjacent native plant communities can be a concern by some land managers. There are approximately 260,000 seeds/lb.

Vetch, Chickling

Lathyrus sativus



Chickling vetch is an annual legume commonly grown and eaten as a grain or forage in many parts of the world but has not been grown in the United States to any great extent. It is a multi-branched straggling to sub-erect vine with grassy-like bladed leaves that grows two to four feet tall with solitary flowers that are reddish-purple, pink, blue, or white in color. It requires approximately 15 inches annual precipitation and is suited to most soil types but does not tolerate low pH. Ac-Greenfix is a variety of chickling vetch developed in Canada that can develop rhizobium nodules on its roots after three to four weeks of growth when plants are about six inches tall. In some parts of the world it grows as a winter annual legume but not in this region. The forage is high in crude protein and digestible

nutrients for livestock forage, but the grain has potential to cause serious illness in animals. It should be seeded as early in spring as possible into moist soil to encourage weed suppression. Broadcast seeding is not recommended. It should be allowed to grow at least 60 days to maximize nitrogen fixation. Chickling vetch can be planted in early August and can withstand temperatures down to 22-26°F. Advertised full seeding rate is 60-100 lbs/ac and 0.25-0.50 inch seeding depth. Inoculation with *Rhizobium leguminosarum viciae* is necessary for plants to fix nitrogen. There are approximately 2,500 seeds/lb.

Vetch, Common

Vicia sativa

Common vetch is a slender, viny plant that can grow to be 23-31 inches (60-180 cm). Common vetch has tendrils that terminate the leaves which are used to attach itself to other plants. Planted alone, vetch has a very prostrate growth habit but it is often planted with grasses and allowed to climb those stems for easier harvesting. Common vetch is an annual legume forage that can contribute to grass, hay, silage, or greenchop systems and is used extensively as a green manure crop. When used as a pasture crop, it can be mixed with small grains or annual ryegrass. Common vetch is less winter-hardy than hairy vetch. It is well-adapted to moderately to well-drained, fertile soils. It is a significant producer of nitrogen, especially for crops planted late in the spring. This makes it very attractive to organic growers. Another trait of vetch is that it lowers the ratio of carbon to nitrogen in mixes with cereal grains. This quickens the process of decomposition. Growth is slow in the fall, but significant in the spring. The full seeding rate is 20-70 lbs/ac and 0.5-2.0 inch seeding depth. Common vetch tolerates pH of from 4.5-8.2. Inoculation with *Rhizobium leguminosarum viciae* is necessary for plants to fix nitrogen. There are approximately 8,000 seeds/lb.



Vetch, Hairy

Vicia villosa



Hairy vetch is a winter annual or summer annual legume. It is the only vetch that can be late summer seeded and reach maturity the following July. When seeded in August, the seed germinates readily and forms a crown before winter but very little top growth takes place. The following spring, the plant produces three to ten long, weak branching pubescent stems or vines reaching three to six feet in length. Purple and white-colored flowers appear in mid-June. Seed pods form in late July. When hairy vetch is spring planted, it will bloom and produce some seed the same season. Hairy vetch is primarily used for soil improvement and for bank stabilization. Well-nodulated hairy vetch can produce 60-120 lbs/ac of nitrogen through fixation. Hairy vetch is also grown for pasture, providing grazing in May and June and has a slightly lower feed

value than clover or alfalfa. It also provides early weed suppression, mulch, improves soil moisture retention and crop root development and enhances soil biological activity. Vetch can

be harvested as hay but cutting, baling, and handling can be difficult because of its vine growth form. Growing hairy vetch along with a small grain supports the weak stems of hairy vetch, reduces lodging, and improves the forage or hay quality. Hairy vetch should not be grown with small grains for grain production because the vetch seed can be difficult to separate from grain during seed processing. About 10-20 percent of hairy vetch seed is hard seed that can lay ungerminated in the soil for several seasons. This can cause a weed problem especially in winter grains. The full seeding rate is 20-60 lbs/ac and 0.5-2.0 inch seeding depth. Inoculation with *Rhizobium leguminosarum viciae* is necessary for plants to fix nitrogen. There are approximately 16,300 seeds/lb.

Warm Season Broadleaf

Buckwheat

Fagopyrum esculentum



Buckwheat is an annual broadleaf that grows rapidly to five feet tall and is frost sensitive. It has hollow stems with alternate arrow-shaped leaves. The flowers are small, white-colored, fragrant and occur in clusters. Buckwheat attracts pollinators, and one of the historical uses of buckwheat was the distinctive tasting honey that it produces. Other historical uses included flour and livestock feed, but its use has declined over the years.

Buckwheat has application in green manure and as a smother crop. Because it is a good competitor and produces a dense leaf canopy, it was used prior to the advent of chemical herbicides to smother weeds. It has been cited as a useful crop for control of quackgrass, Canada thistle, sow thistle, leafy spurge, Russian knapweed and perennial peppergrass in conjunction with tillage. In green manure applications, it can produce two to three tons/ac dry matter after six to eight weeks of growth. It improves physical condition and moisture holding capacity of the soil and has been reported to increase phosphorus availability. Buckwheat grows best where the climate is cool and moist. It is extremely sensitive to freezing temperatures in the spring and fall, and high temperatures and dry weather at blooming time may cause blasting of flowers and prevent seed formation. Allowing buckwheat to go to seed can result in it becoming weedy. Seeding buckwheat is often delayed until three months prior to the first killing frost in the fall to prevent seed set. Buckwheat is best suited to well-drained sandy loam, loam and silt loam and does not grow well in heavy, wet soils

or soils with high levels of limestone. It germinates at temperatures from 45-105°F and emerges three to five days after planting. The full seeding rate for buckwheat is 50-60 lbs/ac and 0.25-0.75 inch seeding depth. There are approximately 14,000 seeds/lb. Due to serious concerns regarding buckwheat allergies, buckwheat should not be planted in areas in rotation with or adjacent to commodity wheat production that will be planted to wheat within the next 2 calendar years.

Chicory

Cichorium intybus

Chicory is a biennial/perennial forb introduced to North America in the late 1700's as livestock forage, and the roots have been harvested and used as a substitute or additive for coffee. It is also planted in wildlife food plots. It is considered to be weedy in some states and is listed as a Class C noxious weed in Colorado. Renewed interest in use as forage has resulted in breeding work for improved forage characteristics from New Zealand researchers.



Chicory is a low growing rosette with broad leaves during the winter and looks very much like dandelion. In the spring it produces large numbers of leaves from the crown. Stems grow one to five feet tall with sparse leaves that are smaller than the leaves from the crown. Showy, bright blue colored flowers are in clusters of one to four on the upper branches. Chicory has a thick taproot. The leafy growth is higher in nutritional and mineral content than alfalfa and provides both spring and summer forage if it is not allowed to flower and produce seed. It can yield up to three tons/ac dry matter forage if managed properly and stands can be maintained for up to 5 years. Chicory is adapted to a wide range of soils but grows best on moderately or well drained soils with pH 5.0-8.2 and is not tolerant of saline conditions. It requires at least 12 inches annual precipitation. Spring planting is most successful (soil temperatures about 50°F), but if seeded in the summer, planting should be completed by early August to allow plants to become established prior to killing frosts (six weeks before frost). The thick taproot could help break soil hardpans and improve soil water infiltration in cover crop applications. It could be mixed with other cover crop species to increase plant diversity. The full seeding rate for chicory is 3-4 lbs/ac. Germination of stored seed can drop rapidly, so fresh seed should be used quickly and not stored from year to year. The small seeds can be drilled or broadcast, but drilling is preferred to provide a more uniform seeding depth of 0.25-0.5 inches. There are approximately 400,000 seeds/lb.

Flower Mix

Species vary



Wildflower mixes can be used in a similar fashion to cover crop mixes. The main difference is that the primary purpose of a wildflower mix is to attract pollinators and other beneficial insects. Adult predatory wasps need nectar and pollen as food sources. Several farmers are using flowering plants in their cover crop mixes, some plant phacelia

in their potato rows. Secondary benefits include a diverse root system which promotes soil health and weed exclusion. Seeding rates depend on the composition of the mixture, but rates ranging from 3 to 10 lbs/ac are common. Seeds/lb varies with mixture components and sowing depth is best from just on the surface to 0.25 inches deep.

Safflower

Carthamus tinctorius

Safflower is an annual, broadleaf oilseed crop that is used to make oil, meal, and birdseed. It is used in rotation with small grains mostly on dry cropland to reduce weedy grasses that have similar life cycles as small grains. There are two types of safflower; oleic acid (high concentrations of monounsaturated fats), used primarily for edible products and linoleic acid (high concentration of polyunsaturated fatty acids), used primarily for industrial oils. The meal that remains after oil extraction is used as a protein supplement for livestock. Safflower is in the same family as sunflower and is adapted to dry cropland (15 inch annual precipitation) or irrigated cropping systems with deep, fertile and well drained soils that have high water holding capacity. Safflower has salinity tolerance similar to barley. It is also productive on coarse-textured soils with low water holding capacity when adequate rainfall is present. When the seed germinates, it produces a central stem that does not elongate for several weeks while developing a rosette of leaves near the ground similar to a young thistle. It is a poor competitor with other plants at this stage. The strong central stem with variable numbers of branches grows 12-36 inches tall. The taproot can grow to depths of eight to ten feet which allows the plant to take up soil moisture and nutrients that are below the root depths of most other crops. Safflower is planted in late April or early May, flower buds form in late June, and flowering occurs in mid to late July. Flowering continues for several weeks with seed enclosed in the head at maturity

which prevents shattering before harvest which usually takes place in September. Safflower could be used as a component of a multi-species cover crop planted in the spring to help improve soil structure, relieve compaction and utilize soil nutrients and moisture that is beyond the depth range of most other crops. The full seeding rate for safflower is 20-25lbs/ac and 1.5-3.0 inch seeding depth. There are approximately 13,600 seeds/lb.

Sunflower

Helianthus annuus

Sunflower is one of the few crop species that originated in North America. Seed is grown commercially for production of edible oils, meal for livestock feed and limited industrial applications such as use in paints, varnishes and plastics. Non-oilseed uses include birdfeed, human snacks, and livestock forage in the form of silage.



Sunflower is an annual, erect (growing 5-12 feet tall) with heart-shaped leaves growing alternate along the stem. The flower head is made up of ray flowers around the circumference without stamens and pistils and the perfect flowers (with stamens and pistils) making up the central portion of the flower head. Sunflower has a strong taproot that can reach a depth of 6.5 feet and a prolific lateral spread of surface roots. It is a good pollinator plant and draws in other insects as well and provides cover and food for birds and other wildlife. Dry matter yield of forage biomass is two to three tons/ac compared to corn which produces seven to ten tons/ac. Sunflower is grown in many semi-arid regions of the world in areas receiving at least 15 inches annual precipitation. Temperatures of at least 46-50°F are required for germination and optimum temperatures for growth are 70-80°F. Temperatures less than 28°F are required to kill mature sunflowers. Sunflower can be used as a component of a cover crop mix planted in spring to help reduce soil compaction and to provide pollinator habitat, cover, and diversity. The full seeding rate for sunflower is three to four lbs/ac and 0.5-1.5 inch seeding depth. There are approximately 7,000 seeds/lb.

Warm Season Grasses

Corn

Zea mays



Published information on commercial corn production and using corn as a cover crop is not available for the intermountain west. Corn is a warm season annual grass that is deep rooted but requires abundant moisture and good fertility for development. Corn can grow from 2-20 feet tall depending on the type and growing conditions. Most varieties planted are hybrids. Three major types of corn are grown in the United States: field or grain corn, mostly used for livestock feed;

silage; and sweet corn consumed mostly by humans. Corn requires soil temperatures of 50°F for germination. Seed that is planted below 50°F will absorb moisture but do not initiate root or shoot growth which leads to seed rot and poor field emergence. Planting rates for corn are determined by desired plant populations which vary from 24,000-32,000 plants per acre and planting rates are provided in terms of seeds/ac and range from 26,000-34,000. Desired plant populations are dictated by type of corn produced as well as row spacing, moisture stress level, soil fertility and yield goal. Recommendations for silage production are 2,000-4,000 plants per acre higher than for grain production. The recommended seeding depth is 1.5-2 inches. Most corn varieties require 100-140 days from planting to full kernel ripeness although some varieties can ripen in as little as 80 days. Corn seedlings are most susceptible to frost after the 2 leaf stage. Prior to the 2 leaf stage, the growing point is below the soil surface and are usually safe. Some corn is actually grown strictly for grazing and University of Idaho research has found that corn can produce from 15,000-20,000 lbs/ac dry matter with a planting rate of 20 lbs/ac. In the Midwest, corn has been used as a cover crop on prevented planting acres, but other cover crops such as sorghum or sudangrass are preferred because of disease, insect and weed management issues. There are approximately 2,500 seeds/lb.

Millet, Foxtail

Setaria italic

Foxtail millet is an annual grass mostly grown for hay or silage often as an emergency hay crop. Some seed is produced for bird feed. It has slender, erect leafy stems that can grow to 50 inches tall. The inflorescence is a dense, bristly panicle resembling weedy foxtail species. The seeds are enclosed in a hull. Foxtail millet grows quickly reaching maturity in 60-90 days but does require soil temperature of 65°F for optimum establishment. It can produce a ton of forage on as little as 2.5 inches of moisture. Foxtail millet has been used when drought has reduced growth of perennial forages; where fall planted grains have been lost to winterkill or hail; where an annual crop is needed to rotate with winter wheat in order to clean up winter annual weeds (cheatgrass);

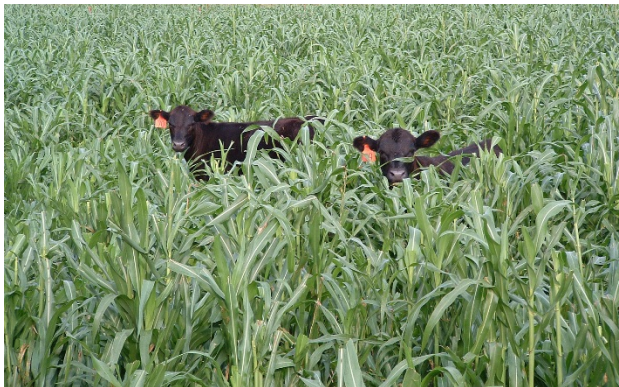
or where there is need for winter cover. Foxtail millet can be planted as late as mid-July and produce a forage crop, but because of its shallow root system, it is not very well suited for grazing. Foxtail millet is a good species for swathing, windrowing and leaving in the field for fall/winter grazing. It is usually cut for hay from the late boot to early bloom stage and protein levels of 12-14% are common. Delaying forage harvest can result in lump jaw or eye injury



to livestock from the bristly seed heads. Millet hay is not suitable for horses. Millet left standing deteriorates badly in forage quality and becomes unpalatable. Foxtail millet grows best on well drained loamy soils with pH > 5.5 and will not tolerate water-logged soils or extreme drought. Because of its quick growth it should be well-suited for cover crop mixes planted in late spring or early summer. It could also be part of an irrigated cover crop mix planted in August. However it would not reach mature growth stage prior to freezing temperatures in the fall. The full seeding rate is 10-30 lbs/ac and 0.25-0.75 inch seeding depth. There are approximately 220,000 seeds/lb.

Millet, Pearl

Pennisetum americanum



Pearl millet is primarily grown as a summer annual forage but some is also grown for livestock feed grain. The major production region is the southeastern coastal plains of the U.S. Pearl millet originates from central tropical Africa and does not grow that well north of about 40 degrees North latitude (central Utah). It has an extensive fibrous root system both laterally and downward into the soil profile. Roots may penetrate 11-12

feet down into the soil but 80 % of the root weight is in the top four inches. Pearl millet grain varieties grow to about 5 feet tall and forage type varieties can grow seven to eight feet tall and have low seed yield. The leaves are long and pointed, flat, dark green in color and up to three inches wide. The inflorescence is a compact, cylindrical, terminal, spike-like panicle and the stems are pithy and 0.4-0.8 inch diameter. For forage quality, pearl millet should not be allowed to grow more than three feet tall before grazing starts and rapidly regrows. It is best-suited for fresh green chop, but is also used as silage. Natural drying for hay production can be difficult in the humid areas where it is grown. Care must be taken to avoid nitrate poisoning to livestock while feeding pearl millet. It is adapted to a wide range of soils, tolerates low pH and fertility,

has a moderate tolerance to drought and is not tolerant to poor drainage or flooding. Soil temperatures should be at least 65°F or warmer before pearl millet is planted. Pearl millet requires at least 16 inches annual precipitation, so an average rainfall of up to 35 inches is optimum. It grows best on fertile, well-drained soils but soil alkalinity can reduce growth significantly. It is very well-suited for sandy soils. Moderately acid conditions (pH 5.5) do not appreciably affect production. It has moderate tolerance to salinity (4-8 dSm-1). The full seeding rate for pearl millet is 4-15 lbs/ac and 0.5-0.75 inch seeding depth. There are approximately 82,000 seeds/lb.

Millet, Proso

Panicum miliaceum



Proso millet was introduced to North America during the 1700's and grown primarily along the eastern seaboard. It is now grown on considerable acreage in North Dakota. It can be grown as far north as 54 degrees North Latitude (Central Canada). The major use of proso millet is in grain mixes for house/hobby birds and wild birds and as livestock feed. It is similar to oats and barley in feeding value and is commonly ground for feeding. Proso millet can be cut for hay but is not as suitable as foxtail millet. Proso

millet grows to about 40 inches tall and has a hollow stem. Stems and leaves are curved with short hairs and has a large open panicle inflorescence. It grows best on well drained loamy soils with pH > 5.5 and will not tolerate water-logged soils or extreme drought and requires soil temperature of 65°F for optimum establishment. It will mature 60-90 days after planting. Proso millet has been used for standing wildlife food plots at the Aberdeen PMC with mixed success. Plants were slow to establish from a spring seeding (likely due to cool soil temperatures) and did not produce much seed. It did however produce adequate amounts of cover. It could be used in spring planted cover crop mixes and should probably grow okay if adequate soil temperature is present at planting. It could also be part of an irrigated cover crop mix planted in August, however it would not reach mature growth stage prior to freezing temperatures in the fall. The full seeding rate is 25 lbs/ac and 0.5-0.75 inch seeding depth. There are approximately 120,000 seeds/lb.

Sorghum, Grain

Sorghum bicolor

Sorghum is the fifth leading cereal grain produced in the world. In the United States sorghum is used primarily as a feed grain for livestock. Its feed value is similar to corn and is usually cracked or rolled for feeding to improve digestibility. Sorghum is beginning to be used in human food products in the U.S because it is gluten-free. Sorghum can also be pastured after grain harvest but care must be exercised to prevent prussic acid and nitrate poisoning of livestock. Sorghum is primarily grown on dryland acreage from South Dakota to south Texas (the Sorghum belt) and the species is introduced from northeast Africa. Sorghum is a warm season annual grass that ranges from two to four feet tall (dwarfing genes reduce leaf/stem biomass to facilitate grain production) to five to seven feet tall (varieties developed before 1940). Sorghum is similar in vegetative appearance to corn, but it has more tillers and finely branched roots than corn. Its growth and development is similar to corn. The seedhead is a panicle with spikelets in pairs and the species is normally self-pollinated. Low temperature, not length of growing season is the limiting factor for grain production. Average temperatures of at least 80°F during July are needed for maximum grain yield and day-time temperatures of at least 90°F are required for maximum photosynthesis. Soil temperature at planting time for grain sorghum is critical with 60-65°F required for good emergence. It is very sensitive to frost. Sorghum requires at least 16 inches annual precipitation or irrigation. It can tolerate soil pH 8.0-9.0 and salinity levels similar to what barley can tolerate. Early maturing varieties have failed to produce mature seed in northern Idaho and would probably struggle in most other areas of the state as well. Sorghum could be included in a cover crop mixture to increase organic matter and suppress weeds. Because of its stature and growth form it can suppress smaller plants, so if weed suppression is a goal of the cover crop, it should be planted alone or with similar statured plants. Sorghum is typically planted in 30-40 inch row spacing for grain production. The full seeding rate at the wide row spacing is 8-10 lbs/ac and 1.0-2.0 inch seeding depth. There are approximately 18,000 seeds/lb.



Sudangrass

Sudangrass was introduced into Texas in the early 1900's from southern Egypt and Sudan and became an important forage crop. It is a fine-stemmed summer annual that is four to six feet tall. The stems are about 0.25 inches diameter with soft, narrow leaves that are 1.5-6 inches long. Sudan grass has a panicle inflorescence. Many improved varieties have been developed with greater disease resistance, sweeter stems, less toxic chemical content and more leafiness. It is used for pasture grazing, green chop and hay. Young, active growing plants contain varying levels of cyanide that break down and release prussic acid or hydrocyanide; when ingested by grazing animal's, sudangrass can be lethal. These compounds form if the plant is stressed from drought, light freeze, or hail. Plants should not be grazed until they are at least 18 inches tall; should not be grazed or fed green chop that have been recently killed by frost; or have been stressed from drought. Plants must be totally dried to allow the cyanogenic compounds to dissipate. Nitrate poisoning can also occur, usually caused by applying high rates of fertilizer in one application. For cover crop applications, sudangrass can scavenge excess soil nitrogen, suppress weeds, break up compacted soil, suppress diseases and nematodes and improve soil quality by adding large quantities of organic matter to the soil. It grows best on well drained loamy soils with pH > 5.5 and will not tolerate water-logged soils or extreme drought and requires soil temperature of 65°F for optimum establishment and is best suited to areas receiving at least 20 inches annual precipitation. It could be used in spring planted cover crop mixes and should probably grow okay if adequate soil temperature is present at planting. It could also be part of an irrigated cover crop mix planted in August, however it would not reach mature growth stage prior to freezing temperatures in the fall. The full seeding rate is 30-50 lbs/ac and 0.25-1.0 inch seeding depth. There are approximately 17,000 seeds/lb.

Sorghum bicolor, *Sorghum x drummondii*



Teff

Eragrostis tef



Teff is an annual grass used as a grain crop for human use primarily in Ethiopia, India, and Australia. It is gaining popularity in the United States as a health food because it is gluten-free and high in fiber and calcium. Teff is also used as a livestock forage in Africa, India, Australia and South America. In the United States, teff for forage is grown on limited acres in the Pacific Northwest and Midwest. Teff is a fine-stemmed, annual bunchgrass that grows 2.5-3.5 feet tall. It has a massive, fibrous, shallow root system and the

inflorescence is an open panicle that produces very small seeds. It is highly susceptible to frost at all stages. In Idaho, it is grown primarily in Owyhee, Canyon, and Washington counties. It is typically planted in early June and is cut two times for hay. The first cutting is about 45-55 days after planting and the second cutting is about 40-50 days following the first cutting. Forage yields can range from three to five tons/ac and requires 6-12 inches of irrigation or at least 17 inches annual precipitation. Seed yields of 15 varieties from a Nevada study ranged from 430-1,543 pounds per acre. Its fast growth, massive fibrous root system, and biomass yield make it a good green manure crop, but it may not be a good choice as part of a mixture. It could also be used as a double crop forage option following small grain harvest if warm growing conditions and water availability extends 50-60 days beyond grain harvest. Teff grows best on well-drained soils but can also grow on poorly drained soils, high pH and salt levels similar to alfalfa. Because the seed is very small, seedbed preparation, soil temperature, and soil moisture are critical for establishment. Seedbed must be smooth and firm, soil temperature 65°F, and adequate soil moisture to germinate seed. The full seeding rate is 5-7 lbs/ac and approximately 0.25 inch seeding depth. There are approximately 1,300,000 seeds/lb.

Appendix. Seeding information for Intermountain cover crop species

Cool Season Grasses (fibrous root system)				
Common Name	Seeds/lb	Full Seed Rate (lb/ac)	Seed Depth (in)	Suggested seed rate in mixes lb/ac
Barley	13,000	50-100	1.0-2.0	10-20
Oat	15,000	50-100	0.75-1.5	10-20
Rye, Cereal	15,000	60-120	1.0-1.5	10-20
Ryegrass, Annual (Italian)	190,000	10-20	0.25-1.0	7-15
Triticale	13,500	60-120	0.75-1.5	10-20
Wheat	11,400	60-120	1.0-2.0	10-20

Cool Season Broadleaf Plants (Taproot)				
Common Name	Seeds/lb	Full Seed Rate (lb/ac)	Seed Depth (in)	Suggested seed rate in mixes lb/ac
Arugula	280,000	4-8	0.25-0.5	1-3
Beet	10,000	1-2	0.75-1.5	2-6
Cabbage, Ethiopian	180,000	8-16	0.25-0.5	1-3
Flax	80,000	30-50	0.25-0.50	1-3
Mustard, Oriental, White	180,000	8-16	0.25-0.5	1-3
Phacelia	225,000	7-12	0.125-0.5	.25-1
Radish, Forage and Oilseed	50,000	6-8	0.25-0.75	.5-2
Rapeseed (Canola)	135,000	5-16	0.25-0.5	1-3
Turnip	215,000	3-5	0.25-0.5	.5-2

Legumes (Taproot)					
Common Name	Seeds/lb	Full Seed Rate (lb/ac)	Seed Depth (in)	Warm/Cool Season	Suggested seed rate in mixes lb/ac
Alfalfa	227,000	10-20	0.25-0.5	Cool	1-3
Bean, Fava (Bell)	3,000	150-300	0.75-2	Cool	10-20
Clover, Crimson	150,000	15-20	0.25-0.5	Cool	1-3
Clover, Red	272,000	4-10	0.25-0.5	Cool	1-3
Clover, White	800,000	4-8	0.13-0.25	Cool	1
Cowpea	3,500	See Desc.	0.5-1.5	Warm	10-20
Lentil	15,000	30-80	1.0-2.0	Cool	5-10
Medic	230,000	10-20	0.25-0.75	Cool	1-3
Pea, Austrian Winter	3,800	30-100	1.5-3.0	Cool	10-20
Pea, Spring	2,000	30-225	1.5-3.0	Cool	10-20
Sunn Hemp	15,000	25-50	0.5-1.0	Warm	5-10
Sweetclover, Yellow and White	260,000	4-10	0.5-1.5	Cool	1-3
Vetch, Chickling	2,500	60-100	0.25-0.5	Cool	10-20
Vetch, Common	8,000	20-70	0.5-2.0	Cool	5-15
Vetch, Hairy	16,300	20-60	0.5-2.0	Cool	3-15

Warm Season Broadleaf Plants (Taproot)					
Common Name	Seeds/lb	Full Seed Rate (lb/ac)	Seed Depth (in)	Suggested seed rate in mixes lb/ac	
Buckwheat	14,000	50-60	0.25-0.75	1-5	
Chicory	400,000	3-4	0.25-0.5	1	Biennial/Perennial
Flower Mix	Varies	3-10	0.25-0.5	.25-1	
Safflower	13,600	20-25	1.5-3.0	1-3	
Sunflower	7,000	3-4	0.5-1.5	1-3	

Warm Season Grasses (Fibrous roots)				
Common Name	Seeds/lb	Full Seed Rate (lb/ac)	Seed Depth (in)	Suggested seed rate in mixes lb/ac
Corn	2,500	20	1.5-2.0	2-10
Millet, Foxtail	220,000	10-30	0.25-0.75	1-3
Millet, Pearl	82,000	4-15	0.5-0.75	2-5
Millet, Proso	120,000	10-25	0.5-0.75	2-10
Sorghum, Grain	18,000	8-10	1.0-2.0	2-10
Sudangrass	17,000	30-50	0.25-1.0	2-10
Teff	1,300,000	5-7	0.25	0.5-1