United States Department of Agriculture
Natural Resources Conservation Service
200 North High Street, Room 522
Columbus, Ohio 43215

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Appendix – A (Cover Crop)

Introduction

This practice guide contains information for planning and applying seasonal vegetative cover according to NRCS Ohio's Conservation Practice Standard Cover Crop (340). Use this guide to develop implementation requirements to apply the practice in the planned location.

References used to develop this guide are listed at the end of the document. The following documents are the primary sources of the characteristics of cover crop species identified in this guide. Review the sources directly for further details needed to meet client objectives and socio-economic considerations.

1. Managing Cover Crops Profitably, 3rd edition, 2007
2. Midwest Cover Crops Council website
3. USDA ARS Cover Crop Chart, V2.1
4. USDA NRCS Plants Database website
5. OSU Bulletin 472 - Ohio Agronomy Guide 14th Edition

Seed Quality

The quality of seed used in conservation practices can have a dramatic effect on the success of the practice. The seeding rate for cover crops used by NRCS in this document assumes a level of seed quality. As a result there may be an adjustment that needs to be added to the minimum seeding rate to account for the site specific seed quality being used if the seed quality does not meet the criteria assumed in the calculation. Additionally, NRCS is committed to preventing the spread of noxious, invasive and herbicide resistant weed species. Therefore all seed used in conservation practices must have a seed tag or be tested for seed quality and percent weed seed prior to use. The use of "bin run" seed is allowed in NRCS conservation practices as long as the seed has been tested, the seeding rate has been adjusted for seed quality if needed and the seed meets the minimum quality as specified in all applicable laws.

Seed Testing

Producers wishing to use uncertified seed sources (bin run, client harvest, or bulk seed sources) for NRCS program practices **must** have that seed tested by a reputable lab that reports the following:

1. Purity
2. Germination
3. % weed seeds

For additional information on seed testing contact:

Ohio Department of Agriculture
Division of Plant Health
Grain, Feed, & Seed Section
8995 E. Main St
Reynoldsburg, OH 43068
Phone: (614) 728-6410

Additional Seed Quility Adjustment Factor[1]

Purity \ Germination	98%	96%	94%	92%	90%	88%	86%	84%	82%	80%
98%	-	-	-	-	-	-	1.02	1.04	1.07	1.11
96%	-	-	-	-	-	1.01	1.04	1.07	1.10	1.13
94%	-	-	-	-	1.01	1.04	1.07	1.10	1.13	1.16
92%	-	-	-	1.01	1.04	1.07	1.09	1.12	1.16	1.19
90%	-	-	1.01	1.04	1.06	1.09	1.12	1.15	1.19	1.22
88%	-	1.01	1.04	1.07	1.09	1.12	1.15	1.18	1.22	1.25
86%	1.02	1.04	1.07	1.09	1.12	1.15	1.18	1.21	1.25	1.28
84%	1.04	1.07	1.10	1.12	1.15	1.18	1.21	1.25	1.28	1.32
82%	1.07	1.10	1.13	1.16	1.19	1.22	1.25	1.28	1.32	1.35
80%	1.11	1.13	1.16	1.19	1.22	1.25	1.28	1.32	1.35	1.39

1. The "additional seed quility adjustment factor" is to be used only if the percent germination and percent purity is lower then the assumed value. Combinations with out numbers (-) do not need an adjustment of the listed seeding rate.

All seeding rates in fig 1 are reported as an actual seeding rate. This seeding rate is based on the assumption of high quality seed with higher levels of germination and purity. The Seed Quality Adjustment Factor table above should be used if the seed quality is lower than the assumed value. The equation below is to be used to adjust the seeding rate to account for the site specific seed quality. If an adjustment factor is not listed in the table for the germination and purity then the specific quality of the seed is equal to or greater than the assumed level and no adjustment is needed.

Listed Seeding Rate (Fig 1) x Adjustment Factor = Actual Seeding rate

Cover Crop Seeding Methods

The method of cover crop establishment can also have a dramatic effect on the success of the practice. Planting cover crops early within the recommended planting date window and at the proper seeding depth and rate with good soil seed contact will reduce the risk of poor and slow establishment. When selecting the cover crop seeding method one should consider the advantages and disadvantages of each available method before implementation. Drilling, narrow row planting, harrow seeding and broadcast seeding before light tillage (rotary harrows, vertical tillage) will result in greater soil/seed contact and improved depth control. Although these methods generally result in improved seed emergence they can be time consuming and limit inter-seeding options. Broadcast seeding and aerial applications of seed on the soil surface are great options to implement cover crops on large acres in a short time and/or inter-seeding into an existing crop. However these methods can have reduced crop emergence as a result of poor soil/seed contact. For this document all seeding rates are assumed to be seeded with some seed depth control; if a method is used that does not have seed depth control such as broadcast or aerial seeding a 20% increase in the seeding rate should be included to account for increased risk of poor emergence.

Cover Crop Seeding Dates

Seeding cover crops within the listed date range is important to reduce the risk of planting failure. Research has found that planting cover crops outside recommended planting dates can have a dramatic effect on final plant stand and overall biomass of the cover crop. Some of these effects may be overcome by increasing the seeding rate if the actual planting date is later in the planting date window. To implement conservation practice, Cover Crop (Code 340), the selected species must be planted within the listed planting date window (figure 1) or up to 2 weeks after the last planting date listed if the seeding rate is increased by 20%. Cover crops planted later than 2 weeks after the last planting date will not meet the requirements of the cover crop standard regardless of seeding rate.

Cover Crop Mixes

Cover crops can provide multiple benefits. For example, they can improve soil health, reduce the risk of nutrient loss, supply nutrients to cash crops, suppress weeds, and produce forage. However, not all cover crop species provide the same benefits. To capitalize of the benefits of individual species use cover crop mixtures to achieve multiple benefits.

Use fig. 2 in this document to evaluate individual species suitability ratings to support practice purposes as a guide in evaluating mixes. After a cover crop mixture is selected use the proportional seeding rates listed in fig 1 to determine the actual seeding rate of each specie in the mix. For example if equal parts Winter Rye, Winter Triticale and Hairy Vetch mixture was selected use the 1/3 proportional rate for each (17, 19, and 5 lb/ac respectively). Insure the sum of the proportions equal at least 1 (1/3 + 1/3 + 1/3 = 1). If addressing water quality (nutrients in surface and ground water) as part of a conservation plan at least ½ of the proportional seeding rate must be non-winter killed cover crop species.

Inoculation of Legume Cover Crops

Legume are able to fix their own nitrogen through a symbiotic relationship with Rhizobium soil bacteria by converting atmospheric nitrogen to plant available nitrogen. The amount of nitrogen produced depends upon the legume species and the amount of soil Rhizobium bacteria. Inoculants are commercially prepared Rhizobium bacteria with certain species and strains associated with each legume plant. Inoculants increase the amount of certain Rhizobium species and strains to enhance nitrogen fixation. To obtain maximum nitrogen production, each legume should be inoculated with the specific Rhizobium bacteria. Producer should follow the manufacturer's recommendations regarding the strain of Rhizobium bacteria and the amount to be added with the legume seed. For more information please refer to: Understanding Inoculants, https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/hipmctn12340.pdf.

Herbicides Persistence and Cover Crops

With the increased awareness of herbicide resistance and other problematic weeds many herbicide programs are including long lasting residual herbicides. Herbicides applied to the previous crop can have an effect on the next crop or the following cover crop. These types of herbicides may affect stand establishment and growth of sensitive cover crop species. The desired benefits from planting a cover crop may not be realized if an adequate stand is not achieved.

There are two major factors in determining the potential carryover injury to the next crop. First of all; how long does the herbicide last or persist in the soil assuming that it has soil activity. Several factors influence the rate of dissipation such as rainfall, soil texture and soil pH, etc., however, most guidelines generally are for "normal" conditions (e.g. not severe drought or abnormally wet seasons). Secondly, species sensitivity can play a role if only a small amount of residue is necessary to cause injury and the herbicide persists. Quite often, small seeded legumes like the clovers and small seeded grasses like ryegrass and mustard species like canola are very sensitive to some herbicides.

Herbicides Persistence

Producers wishing to incorporate cover crops into their cropping system should consider current herbicide program. Careful consideration should be given to herbicides used and cover crop specie selection to reduce the risk of carryover effecting cover crop establishment.

Producers should consult and follow:

1. herbicide labels
2. CCAs and private crop consultants
3. herbicide retailers
4. experienced cover crop producers

When implementing a new cropping system that includes cover crops careful consideration should be given to herbicides used and cover crop specie selection. Producers should consult CCAs, private crop consultants, herbicide retailers and/or other experienced producers in making these important decisions. Producers should always follow herbicide label recommendations and restrictions. The ultimate goal is to develop an overall system that meets the weed control objectives while allowing timely cover crop establishment with the desired species. Producers may need to consider altering herbicide programs or cover crop specie selection to meet these goals.

Cover Crop Termination

Cover crops can be terminated by many methods and careful consideration should be consider when determining the correct termination method and timing. Mowing, tillage, frost, crimping, and/or herbicides singularly or in combination in preparation for the subsequent crop can be used effectively to terminate cover crops. Termination should be planned after sufficient growth is achieved to meet the goals of the practice but consideration should also be given to soil moisture status and the ability of the equipment to manage the cover crop residue. In addition, producers should be compliant with NRCS Cover Crop Termination Guidelines and discuss new cropping systems with their local crop insurance agent before implementing any new cropping system.

Fig 1. Cover crop seeding dates, seeding rates and seeding depths.

		Seeding rate (lb/ac)[1]							Planting Date Range[2]	
Plant Species	Life cycle[3]	Pure Stand	¾	½	⅓	¼	Forage Stand	Seeding depth (in)	Northern	Southern
Cool-Season Growth										
Non-Legumes										
Winter Rye (Secale cereale)	nwk	50	38	25	17	13	88	¾ to 1 ½	8-1 to 11-1	8-15 to 11-15
Winter Barley (Hordeum vulgare)	nwk[4]	59	44	29	19	15	-	¾ to 1 ½	8-15 to 10-10 or 3-15 to 5-1	8-25 to 10-20 or 3-1 to 4-20
Winter Wheat[5] (Triticum aestivum)	nwk	64	48	32	21	16	94	¾ to 1 ½	9-22 to 10-22	9-30 to 11-1
Winter Triticale (× Triticosecale)	nwk	60	45	30	20	15	94	¾ to 1 ½	8-1 to 10-22	8-15 to 11-1
Spelt[5] (Triticum aestivum var. spelta)	nwk	64	48	32	21	16	94	1 to 1 ¾	9-22 to 10-22	9-30 to 11-1
Annual Ryegrass (Lolium multiflorum)	nwk[4]	18	13	9	6	4	28	¼ to ½	8-1 to 9-20 or 3-15 to 5-1	8-1 to 9-30 or 3-1 to 4-20
Oats (Avena sativa)	wk	40	30	20	14	10	88	½ to 1 ½	8-1 to 9-20 or 3-15 to 4-30	8-1 to 9-30 or 3-1 to 4-15
Oilseed Radish (Raphanus sativus)	wk	-	-	-	2	1.5	12	¼ to ¾	8-1 to 9-15 or 3-15 to 4-30	8-15 to 9-30 or 3-1 to 4-15
Rapeseed/Canola/Kale (Brassica napus)	nwk[6]	4	3	2	1.5	1	8	¼ to ½	8-1 to 9-15 or 3-15 to 4-30	8-15 to 9-30 or 3-1 to 4-15
Mustards (Brassica juncea)	wk	4	3	2	1.5	1	8	¼ to ¾	8-1 to 9-15 or 3-15 to 4-30	8-15 to 9-30 or 3-1 to 4-15
Turnip (Brassica rapa)	wk	2.5	2	1	.75	.5	6	¼ to ½	7-20 to 9-15 or 3-15 to 4-30	8-1 to 9-30 or 3-1 to 4-15
Legumes										
Alfalfa (Medicago sativa)[7]	nwk	16	12	8	6	4	-	¼	4-1 to 5-1 or 8-1 to 8-15	3-30 to 4-25 or 8-1 to 8-30
Red Clover *(Trifolium pretense)*	nwk	9	7	5	3	2	-	¼ to ½	7-20 to 8-30 or 2-1 to 5-1	8-1 to 9-15 or 2-1 to 4-15
Yellow Sweet Clover *(Melilotus officinalis)*	nwk	8	6	4	3	2	-	¼ to ½	7-20 to 8-30 or 2-1 to 5-1	8-1 to 9-15 or 2-1 to 4-15
Crimson Clover *(Trifolium incarnatum)*	nwk	12	9	6	4	3	-	¼ to ½	6-15 to 9-15	6-1 to 9-30
Winter Pea *(Pisum sativum)*	wk	40	30	20	14	10	-	1 to 1 ½	8-1 to 9-15 or 3-10 to 4-30	8-1 to 10-1 or 3-1 to 4-20
Hairy Vetch *(Vicia villosa)*	nwk	16	12	8	5	4	-	½ to 1 ½	8-1 to 9-20 or 3-10 to 4-30	8-1 to 10-1 or 3-1 to 4-20
Warm-Season Growth										
Non-Legumes										
Sorghum-Sudangrass *(Sorghum bicolor x S. 2udanese)*	wk	24	18	12	8	6	35	½ to 1 ½	5-15 to 7-5	5-1 to 7-15
Sudangrass *(Sorghum bicolor)*	wk	20	15	10	7	5	25	½ to 1 ½	5-15 to 7-20	5-1 to 7-30

		Seeding rate (lb/ac)[1]							Planting Date Range[2]	
Plant Species	Life cycle[3]	Pure Stand	¾	½	⅓	¼	Forage Stand	Seeding depth (in)	Northern	Southern
Pearl Millet *(Pennisetum Glaucum)*	wk	12	9	6	4	3	23	½ to 1	5-15 to 7-20	5-1 to 7-30
Japanese Millet (*Enchinochloa frumentacea)*	wk	14	11	7	5	4	28	½ to ¾	5-15 to 7-20	5-1 to 7-30
Buckwheat *(Fagopyrum esculentum)*	wk	-	-	12	8	6	-	½ to 1 ½	6-15 to 8-15	6-1 to 8-1
Sunflower *(Helianthus annuus)*	wk	-	-	-	4	3	-	1 ½ to 2 ½	5-15 to 7-20	5-1 to 8-1
Legumes										
Cowpea *(Vigna unguiculata)*	wk	60	45	30	20	15	-	½ to ¾	6-15 to 8-1	6-1 to 8-15
Sunn Hemp *(Crotalaria juncea)*	wk	12	9	6	4	3	-	½ to 1 ½	6-15 to 8-1	6-1 to 8-15
Berseem Clover *(Trifolium alexandrinum)*	wk	11	8	5	3	2	-	¼ to ½	5-15 to 8-15	5-1 to 8-15
Soybean (Glycine max)	wk	54	40	27	18	13	-	1 to 2	6-15 to 8-15	6-1 to 8-30

1. Seeding rates are listed as "pure stand" with the assumption to be seeded with some seed depth control; if a method is used that does not have seed depth control such as broadcast or aerial seeding a 20% increase in the seeding rate should be included to account for increased risk of poor emergence. The ¾, ½, ⅓ and ¼ seeding rates are to be used in creating mixes. The forage stand rate are to be used if the cover crop is to also serve as a livestock forage. If a rate is not listed (-) the seeding selected is generally not recommended.
2. Northern Ohio is generally north of I70 and Southern Ohio is generally south of I70.
3. wk = winter killed cover crops; nwk = non-winter killed cover crops
4. Non-winter killed only when planted during the fall dates.
5. Do not plant until after the Hessian fly free date; dates varies from Sept 22 in northern Ohio to Oct 5 in southern Ohio. Wheat and spelt cover crops can be planted up to 20 days past the fly free date. See the Ohio Agronomy Guide for specific county dates.
6. Fall planted varieties planted in the fall are "non-winter killed"; spring planted varieties planted in the fall or spring are winter killed.
7. In order to meet the intent and definition of cover crops (seasonal vegetative cover) alfalfa must be terminated and managed as an annual. Alfalfa planted to provide forage for multiple seasons should be implemented under forage and biomass planting (512).

Fig 2. Cover crop plant species suitability ratings to support practice purposes (Midwest Cover Crops Field Guide, 2nd edition, 2014).

Ratings: 0= no information, 1= Poor, 2=Fair, 3=Good, 4=Excellent

	Practice Purposes						
Plant Species	Reduce Erosion[1]	Increase soil health & organic matter[1]	Utilize (scavenge) excess nutrients[2]	Suppress weeds/pests	Minimize Compaction[3]		N fixation[4]
					Subsoil	Surface soil	
Cool-Season Growth							
Non-Legumes							
Winter Rye	4	4	4	4	2	3	N
Winter Barley	4	3	3	3	3	3	N
Winter Wheat	4	3	3	3	2	2	N
Winter Triticale	4	3	3	3	2	2	N
Spelt	4	3	3	4	0	3	N
Annual Ryegrass	4	4	4	2	4	4	N
Oats	4	3	3	4	3	3	N
Oilseed Radish	1	3	4	3	4	3	N
Rapeseed/Canola/Kale	1	2	3	2	2	3	N
Mustards	3	3	2	3	1	3	N
Turnip	1	1	3	3	0	3	N
Legumes							
Alfalfa	3	4	1	2	4	2	Y
Red Clover	3	4	1	3	2	3	Y
Yellow Sweet Clover	3	4	1	3	4	4	Y
Crimson Clover	3	4	1	2	2	3	Y
Winter Pea	2	2	1	2	1	3	Y
Hairy Vetch	2	3	1	3	2	3	Y
Warm-Season Growth							
Non-Legumes							
Sorghum-Sudangrass Hybrid	4	4	4	4	2-4[5]	2-4[5]	N
Sudangrass	4	4	4	3	1-3[5]	2-4[5]	N
Pearl Millet	4	3	4	3	2-3[5]	1-3[5]	N
Japanese Millet	4	3	4	2	1-3[5]	1-3[5]	N
Buckwheat	1	2	1	4	0	3	N
Sunflower	3	3	4	3	3	1	N
Legumes							
Cowpea	4	2	1	4	2	3	Y
Sunn Hemp	3	3	1	3	3	3	Y
Berseem Clover	3	4	1	2	1	3	Y
Soybean	4	2	1	4	2	2	Y

1. Cover crops effect on soil erosion and soil organic matter will be evaluated with current NRCS prediction tools (RUSLE 2).
2. Cover crops that utilize (scavenge) excess nutrients may not address water quality if there is a lot of time between when they are killed and the next crop's utilization of the nutrients.
3. Cover crops can be used to minimize soil compaction but should be planned with other practices and/or management techniques to minimize the future damage.
4. All legume cover crops should be inoculated with the proper inoculant to maximize growth.
5. For Warm-Season grasses, subsoil and surface soil compaction depends upon management factors like mowing and grazing which increase root mass and decrease soil compaction.

References

Managing Cover Crops Profitably, 3rd edition, 2007; http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition

Midwest Cover Crops Council website; http://www.mccc.msu.edu/

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USDA ARS Cover Crop Chart, V 2.1; http://www.ars.usda.gov/Main/docs.htm?docid=20323

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USDA-NRCS, Understanding Inoculants, Technical Notes, September 2014. https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/hipmctn12340.pdf