Making the Most of Cover Crop Mixtures

Charlie White, Penn State Extension
501 ASI Building, University Park, PA 16802
cmw29@psu.edu

Introduction

Cover crops are an important tool that farmers can use to generate benefits and services on the farm and for society, including improved soil health, nutrient supply to cash crops, weed suppression, insect pest management, forage production, pollinator resources, and clean water and air. There are many different cover crop species to choose from, and each cover crop species has different abilities to provide the services described above. Planting a mixture of cover crop species is one strategy that can be used to enhance and diversify the benefits that a cover crop provides. This article will describe some of the basic concepts to consider when planning a cover crop mixture, such as meeting different farm management objectives, selecting complementary species, and methods for establishing cover crop mixtures.

Tailoring a Cover Crop Mixture to Farm Management Objectives

Every farm is different, and even within a farm, management objectives for a given field and crop will vary based on weather, site history, crop rotations and many other factors. The design of a cover crop mixture must, therefore, take into account the current and future management objectives for each field. Individual species of cover crops often excel at providing only one or two functions, so meeting multiple objectives may require the inclusion of several species. Table 1 lists many of the common cover crop species used in the Northeastern US, their relative ability to provide different services, and recommended planting date windows.

Enhancing Services Through Increased Cover Crop Biomass

Many of the services provided by cover crops, including nitrogen retention, nitrogen supply, weed suppression, and erosion control are regulated by cover crop biomass production. Increasing the rate, total quantity, and time period of cover crop biomass production will increase the provisioning of these services. To design a cover crop mixture with increased potential for biomass production, choose species with complementary growth periods, growth forms, and nutrient acquisition strategies.

Complementary growth periods. Cover crops can be divided into winter-killed species and winter-hardy species. Winter-killed cover crops often exhibit the ability to grow rapidly in the late summer and fall before dying due to cold temperatures. Rapid fall growth increases nitrogen uptake, weed suppression, and erosion control in the fall and winter. However, after winter-killing, services provided by the cover crop begin to diminish. Cover crop nitrogen uptake ceases at winter-kill, and weed suppression and erosion control will diminish as residues from the cover crop decompose on the soil surface.

Winter-hardy cover crops are the most common class of cover crops used in the Northeastern US. Depending on the planting date, winter-hardy cover crops will only produce a small-to-moderate quantity of biomass prior to going dormant for the winter, with the majority of growth occurring in the spring. When the cover crop planting date allows for successful establishment of a winter-killed species, mixing a winter-killed and winter-hardy species creates a mixture with complementary growth periods that can maintain the provisioning of cover crop services throughout the fall, winter, and spring.

Complementary growth forms. Different species in a cover crop mixture can compete with each other for space and light, reducing the potential for increased biomass production by a mixture. Selecting species with complementary growth forms helps to alleviate competition between species. Cover crop growth forms can be divided into several categories, including tall open canopies, short dense canopies, and vining (See Table 1). Species with the same growth form are likely to be competitive while species with different growth forms are likely to be complementary. Tall open canopied species are especially compatible with vining species as the tall canopied species creates a ladder that the vining species can grow up. It is important that species with tall open canopies are not planted too densely, or they will shade out too much light for successful establishment of understory species. It should also be noted that some cover crop species will shift their growth form from a short dense canopy to a tall open canopy when maturing from vegetative to reproductive stages.

As an example, cereal rye and crimson clover both have short dense canopies, so they are in competition for the same space. Replacing cereal rye with a tall open canopied grass such as sorghum-sudan grass, or replacing crimson clover with a vining species such as Austrian winter pea would create a more complementary mixture. The pea-rye mixture has the added dynamic that the rye will shift from a short dense canopy to a tall open canopy as it enters reproductive phases in the spring, giving the pea a ladder to grow up.

Complementary nutrient acquisition strategies. Legume cover crops can obtain nitrogen from the soil and atmosphere while non-legume cover crops such as grasses and brassicas can only obtain nitrogen from the soil. Although legumes can take up soil nitrogen, they are less aggressive at doing so than grasses and brassicas. Because low soil nitrogen levels can limit cover crop and cash crop growth while excessive soil nitrogen levels can stimulate weed growth and contribute to nitrate leaching, the level of soil N availability should be taken into account when planning the cover crop mixture. Sometimes it is beneficial to pair species with different nitrogen acquisition strategies while other times only a single cover crop type may be necessary.

For soil with low nitrogen levels, legume cover crops that can satisfy their nitrogen demand from the atmosphere will be most effective. For soils with excessive nitrogen levels, non-legumes that are aggressive at scavenging soil nitrogen should be used. Planting a legume cover crop in a soil with excessive nitrogen levels will lead to a weak cover crop stand that does not prevent nitrogen leaching and is susceptible to weed invasions. Conversely, planting a non-legume into a soil with low nitrogen levels will result in sub-optimal biomass production due to nitrogen deficiency. In soils with moderate nitrogen levels, a mixture of a legume and non-legume can work well, as the non-legume will take up the soil N, protecting it against leaching, while the legume brings in N from the atmosphere, adding it to the plant-soil ecosystem. If the N level of a soil is not known, planting a cover crop mixture can be a useful strategy, as the performance of the mixture will adapt to the existing soil conditions. When large amounts of soil N are available, grasses will be favored and legumes may not establish well. With low soil N availability, legumes will be favored. This dynamic tradeoff between grasses and legumes allows the cover crop to adapt to the N management service needed most.

Enhancing Services with Specific Cover Crop Species

In the previous section we focused on how to achieve increased cover crop biomass production with mixtures in order to facilitate services generally associated with biomass production. Some services provided by cover crops are not necessarily associated with biomass production, but rather with some characteristic unique to a certain species. An example of this might be the ability of forage radish cover crop roots to penetrate compacted soils, the high forage quality of annual ryegrass, or flowers that attract pollinators and beneficial insects.

When the traits of a specific species are desired, it is necessary to evaluate the extent to which that species is needed in the mix to provide its service and adapt the companion species as necessary. For example, if high quality forage is needed from annual ryegrass in the mix, the annual ryegrass should not be diluted too much by other species. On the other hand, just a few canola plants or sunflower plants scattered throughout a cover crop mixture can supply significant floral resources for pollinators and beneficial insects. When evaluating the extent to which a certain species will be able to compete in a mixture, look to the rules of thumb on complementarity described in the previous section to determine compatible species for the mixture.

Methods to Establish Cover Crop Mixtures

The common tools and methods of cover crop establishment, such as drills and broadcasting, can all be adapted for the successful establishment of cover crop mixtures. Some of the challenges and opportunities associated with establishing cover crop mixtures include achieving the correct seeding depth, preventing seed separating and settling in the drill box, selecting different row configurations, and determining the right seeding rate of each species in the mixture.

Seeding depth. Cover crop species vary in their optimum seeding depth from 0.25 inch to 1.5 inches. When species with different seeding depths are mixed together, there are several strategies that can be used to aid in successful establishment of each species.

Many drills have a large and a small seed box. The large box, sometimes called the grain box, is optimized for large seeded crops and the drop tubes from the large box direct seeds to the deepest point in the furrow created by the disc openers. The small box, sometimes called the legume or grass-seed box, is optimized for small seeded crops. The drop tubes from the small seeded box can be directed to drop seed at the rear of the disc openers, resulting in a shallower seed placement. The drop tubes from the small box can also be left hanging straight down to dribble seed on the soil surface. This can be a useful strategy in tilled soil where a cultipacker will be used to firm the soil after seeding. Small seeded species with shallow planting depths can be placed in the small seed box while large seeded species with deeper planting depths can be placed in the large seed box. This approach has been the most effective strategy at obtaining optimum seeding depths for various species in the mixture.

An alternative approach to seeding depth management that has been proposed is to mix the seed of all species in the mix in one drill box and to set the seeding depth to approximately 0.75 to 1 inch. The suggestion has been made that in a mixture, the larger seeded species planted to such a depth will break open the seed furrow as they germinate, allowing the smaller seeded species to then emerge. This approach sometimes works, and may be the only solution for drills with a single seed box. However, on occasion, it has led to sub-optimal stands of smaller seeded species, particularly when the depth of the furrow is likely to change across a field due to variations in soil type and soil moisture.

A final approach that has been used, which is more time and equipment intensive than other approaches, is to seed the large seeded species to depth with a drill and then to make a second pass with a broadcast seeder, broadcasting the small seeded species onto the soil surface and firming in with a cultipacker.

Preventing seed separating and settling. Seeds of different sizes, mixed together in a drill box, may be subject to separating and settling as the drill travels across a field. While this concern is commonly raised as a question, it has rarely been a significant issue in practice. The seed sizes that are most likely to separate from each other when mixed together are small round seeds and large round seeds. When intermediately sized or differently shaped seed are introduced to a mix such as this, the packing arrangement becomes stabilized and seed separation is greatly reduced. If a diversity of different seed sizes and shapes are mixed together, seed settling is unlikely to occur. Another approach to minimize seed settling would be to separate seeds into the small and large boxes of a drill as discussed in the seeding depth section.

Selecting different row configurations. One of the opportunities that emerges with using cover crop mixtures is to plant different component species of the mixture in specific row configurations. This strategy can be used to minimize competition between species in a mixture. One common example is to plant forage radishes in alternating rows with a companion species. On a drill with 7.5" spacing between rows, a good row configuration might be 1 row of radish alternating with 3 rows of the companion, or 2 rows radish alternating with 2 rows of the companion. Because forage radish has the tendency to outcompete other species in a mix, segregating the radishes and companion species into different rows allows the companion species to establish.

Another reason to use specific row configurations is to concentrate the impacts of a certain species in the mix in strips across the field. An example of this approach would be to drill forage radish in strips 30 inches on center and then plant rows of a cash crop on top of the radish strips the following year. Because forage radish residues decompose quickly and the taproots alleviate compaction, the strips of soil where radish were growing will be warmer, more friable, and with greater nutrient availability, creating favorable seedbed conditions for the next crop. A different species could be planted between the radish rows, such as cereal rye, which could make up for some of the forage radish's drawbacks by continuing to grow in the spring, taking up nutrients, and providing more persistent residue cover.

Alternating row configurations can easily be created in a drill with two seed boxes. Simply place duct tape over openers inside each seed box to create the desired pattern and then place the set of seeds for each row type in the appropriate box. In a drill with one seed box, vertical baffles between openers, spanning front to back of the drill box, can be created with cardboard and duct tape. Fill each compartment created by the baffles with the appropriate seed to create the desired row configuration.

Determining seeding rates in the mixture. Determining appropriate seeding rates of each species in a mixture can be difficult. Start with the suggestions below, plant a small acreage, observe the results, and then make adjustments as necessary. Be aware that results will vary across fields, years, and climate zones.

Certain species are highly competitive against other species in a mix, including forage radish, canola, oats, and sorghum-sudan grass. Seeding rates of these species must be dramatically reduced to prevent them from dominating the mixture. Successful seeding rates for these species in mixtures are 2 to 3 lbs/acre for forage radish, 3 to 4 lbs/acre for canola, 15 to 20 lbs/acre for sorghum-sudan grass and 20 to 40 lbs/acre for oats.

Seeding rates for other grasses in a mixture can safely be reduced to between half and one-quarter of monoculture seeding rates to achieve a balanced stand with legumes and other broadleafs. Legume components of a mixture, which tend to be weak competitors, are more safely kept towards their monoculture rates to ensure establishment in the stand.

When two or more species that share a similar growth period, growth form, and nutrient acquisition strategy are included in a mix with other types of cover crops, seeding rates of the similar cover crop types should be reduced even further. For example, to determine seeding rates of the winter-hardy grasses annual ryegrass, cereal rye, and triticale in a mixture with crimson clover and oats, first consider the winter-hardy grasses as a group of grasses whose seeding rate should be reduced in half from a monoculture rate. Then, because the 3 similar species of grasses share essentially the same functional properties, divide the half rate for each species by the number of similarly functioning species, in this case 3, to obtain a final seeding rate in the mix. In this case, monoculture rates of 20 lbs/acre for annual ryegrass, and 120 lbs/acre for cereal rye and triticale would first be cut in half and then divided by 3, such that final rates of approximately 3.3 lbs/acre annual ryegrass, and 20 lbs/acre each of cereal rye and triticale would be used.

Conclusions

The benefits of cover crops have been known for decades, and as more and more farmers adopt cover cropping innovations such as using cover crop mixtures will continue to occur. By tailoring the selection of cover crop species to meet farm management objectives, understanding complementarity between species, and following some basic management guidelines, an endless array of cover crop mixtures can be designed and implemented in any farming system. As with any new endeavor, observing the results and making adjustments based on previous experiences are important keys to long-term success when using cover crop mixtures.