Cover Crops in Modern Agriculture

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Background

Cover crops are commonly planted between crop rows (Figure 1), known as alleyways, to minimize weed growth and mitigate erosion, runoff, nutrient depletion, and soil compaction. Moreover, cover crops offer a range of additional advantages. They contribute to the enrichment of:

a. Soil organic matter and nutrient content,

b. Mitigate the soil compaction, improve soil water infiltration rate, and water-holding capacity,

c. Suppress insects by providing habitat for beneficials,

d. Attract pollinators more effectively, increase biodiversity and native wildlife, and

e. Serve as trap crops to deter pests

Figure 1. Intercropping main crop (corn) with cover crops

Cover crops can also serve as a valuable forage option. Later in the season, cover crops can be conveniently left on the ground, acting as a natural mulch and facilitating the recycling of nutrients back into the soil, effectively functioning as a form of "green manure" (Figure 2).

Figure 2. Cover crop as green manure (grass-legume mix)

Uniform application of precision agricultural (PA) practices without considering field variation can diminish the effectiveness and productivity of this technology. In the context of cover crops, the initial step is to identify the appropriate mixture based on the specific needs of the field and apply it in the right amount to maximize the benefits of these practices. PA tools and technologies such as the EM-38 Sensor, aerial imagery, and remote sensing aid in identifying field variations, enabling better decision-making when cultivating cover crops. The advantages of this approach are multifaceted. Due to the enhanced effectiveness of the services provided, there is a reduced need for fertilizers and herbicides, leading to a decrease in chemical loss to the environment. The right timing of operations reduces labor time and costs, resulting in a higher return on investment. Additionally, the correct selection and management of cover crops not only prevent nutrient deficiencies for the next crop but also enhance nutrient availability and contribute to greater environmental sustainability through soil health improvement.

Utilizing PA tools to detect hotspots of weeds and diseases and applying non-host cover crops can significantly mitigate these issues in a conservative manner. Satellite imagery and remote sensing offer clearer insights into field topography and aspects, allowing for the use of different mixtures and seeding rates to achieve a uniform stand in the field. This strategy is not only beneficial for achieving greater biomass of crops but also aids in soil aggregation.

Planting specific cover crops with denser roots on the steep slopes protect soil against erosion, in addition to adding more organic matter. Recognizing right management zones within a field, using sensors and GIS programs, also facilitates more efficient residue management.

Cover crops types

Based on cover crops properties and potential applications, they can be categoried as below:

Grasses

This category consists of annual cereals, such as rye, barley, corn, oats, wheat and so on. These cover crops exhibit rapid growth and produce high residue levels. Their root systems produces fibrous, threadlike structures which can provide effective protection against erosion.

Legumes

This category includes leguminous cover crops including white clover, cowpeas, alfalfa, fava beans, hairy vetch, and etc. Legumes are renowned for their ability to enrich the soil with nitrogen. In addition, their robust taproot systemscan effectively mitigate unwanted subsurface compaction.

Broadleaf non-legumes

This type of cover crops includes forage radishes, marigold, brassicas, turnips, mustards. However, when utilizing non-legume cover crops for fall planting, it is important to implement appropriate treatments to address weeds prior to seed establishment.

Considering the typical planting schedule of cover crops after cash crop harvest, the climatic conditions during fall and winter are crucial. In the upper Midwest, according to the USDA Winter Hardiness Zone classification, most areas fall within zones 3A to 5B. These zones often experience prolonged and harsh winters, presenting challenges in selecting cover crops that can withstand such freezing conditions. Despite the availability of various cover crop options, growers must carefully choose species suited to their specific area. The USDA Plant Hardiness Zone Map serves as a valuable tool, indicating the likelihood of a crop surviving the average winter in a given area. Based on this information, common cover crops that can endure the conditions in hardiness zones 3A to 4B are detailed in (Figure 3).

Figure 3. Common Cover Crops Suitable for Hardiness Zones 4A to 5B (A: Flax, B: Red Clover, C: Rape Seed, D: Tillage Radishes; E: Turnip, F: Sorghum, G: Hairy vetch, H: Cereal Rye)

Cover crops management with precision agriculture

Precision agriculture can significantly benefit cover crop management in several ways:

a. Site-specific planting and management: precision agriculture technologies enable farmers to precisely map and plan the placement of cover crops in their fields. This ensures optimal coverage and allows for targeted management practices, such as variable-rate seeding and fertilization, tailored to the specific needs of different areas within a field. By strategically placing cover crops, farmers can maximize their benefits and address specific soil and crop requirements.

b. Nutrient management: precision agriculture techniques, including soil sampling and remote sensing, can provide detailed information about soil nutrient levels and variability within a field. This data helps in determining the appropriate timing, type, and amount of fertilizer to be applied to cover crops. By accurately managing nutrient inputs, farmers can enhance the growth and effectiveness of cover crops, optimizing their nutrient cycling and soil improvement capabilities.

c. Irrigation management: precision agriculture utilizes soil moisture sensors and real-time data to monitor soil moisture levels. This information allows farmers to optimize irrigation practices for cover crops, ensuring they receive the right amount of water when needed. Proper irrigation management promotes healthy cover crop growth, improves water-use efficiency, and reduces the risk of over- or under-watering.

d. Weed and pest management: precision agriculture technologies, such as remote sensing and imaging, can help detect early signs of weed or other pest infestations in cover crops. This early identification allows for targeted interventions and the application of appropriate herbicides or pest control measures, minimizing the impact on both cover crops and cash crops.

e. Harvest and termination timing: precision agriculture tools, such as yield monitors and data analytics, can help determine the optimal timing for cover crop termination and subsequent cash crop planting. By analyzing crop growth and yield data, farmers can make informed decisions about when to terminate cover crops to maximize their benefits while ensuring a smooth transition for the following crop.

With integrating precision agriculture provides valuable data and tools for precise planning, nutrient management, irrigation optimization, weed and pest control, and timing decisions related to cover crop management (Figure 4). By integrating precision agriculture techniques with cover crop practices, farmers can enhance the effectiveness and efficiency of their cover crop systems, leading to improved soil health, reduced environmental impacts, and higher overall farm productivity.

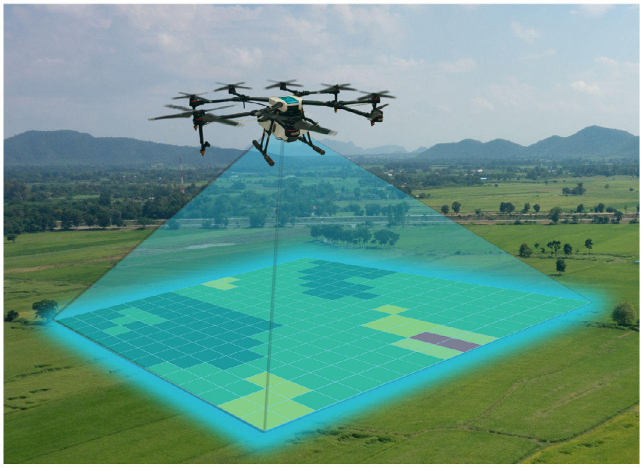

Figure 4. Remote sensing cover crop performance using precision agriculture technologies.

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