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Impacts to Soil Moisture and Nutrients from Winter Wheat Cover Crops as a Post Wildfire Rehabilitation Practice

Abstract

Wheat producers in the western United States are increasingly dealing with wildfires burning in wheat due to increased crop residue from no till farming practices, additional human ignitions, and extreme fire weather conditions. Wildfire rehabilitation practices have been heavily examined in forested systems, but less so in agricultural production. Wheat cover crops have recently been used in crop fields across the region to reduce soil erosion following severe wildfires. However, little research has examined impacts of wheat cover crops to soil moisture and soil nutrients as a post wildfire rehabilitation practice. Therefore, research in 2022 focused on the use of wheat cover crops in a severely burned wheat field. Soil moisture was monitored May through September in a side-by-side comparison between non-burned fallow areas, burned with a post-fire cover crop, and burned without any post-fire vegetative cover. Soil nutrients were also analyzed in soil samples in August. Soil moisture was similar in cover cropped and non-covered areas in the top 6 inches, but was slightly lower from 6-12 inches where a cover crop was planted, and highest in the non-burned fallow areas. Nitrate nitrogen increased in the top 6 inches in areas burned without a cover crop, while other nutrients showed less variability. Soil organic matter was increased by the cover crop, by nearly 0.5%, in the top foot of soil. Using wheat cover crops for post wildfire rehabilitation in

crop fields appears to be a good strategy for increasing soil organic matter with minimal impacts to soil moisture, if terminated early.

Introduction

Wildfires have increased in size and frequency across rangelands and croplands in Western North America over recent decades (Brooks et al., 2004; Shinneman et al., 2018). In 2018, nearly 120,000 acres of dryland wheat, pastures, and rangeland burned in north central Oregon. Similar fires have occurred in California, where pastures, vineyards, and other agricultural crops are being impacted by wildfires more frequently (California State Assembly Committee, 2020; Pinzón et al., 2025). The increase in the frequency and size of wildfires in agricultural areas is due to several factors, including increasing human starts, heavy continuous fuel loads of annual grasses, and changing farming practices (Li et al., 2021; Powell 2025).

Cereal grain crops are large continuous crops that cover much of Oregon, Washington, and Idaho with 4.2 million acres of wheat harvested each year valued at \$2.1 billion (Hagerty et al., 2023). Most crop producers in the United States now use no till farming practices where residue from previous crops is left standing and the next crop seeded through it. This has dramatically reduced soil erosion; however, it has placed more fuel across the landscape contributing to wildfire spread, especially in areas using a wheat-fallow rotation system. In a dryland wheat fallow rotation system, the field is harvested in the summer and then fallowed for one year before being planted with another crop that following fall. Most farmers growing wheat in the western United States with less than 14 inches of annual precipitation use this rotation system (Schillinger & Papendick, 2008). Before no-till farming practices were used, most fallow fields were tilled to control weeds. Under no-till farming, weeds are controlled in fallow using herbicides (chemically fallowed). As a result, fallow fields that used to work as effective fuel breaks now contribute to wildfire spread. In addition, when no-till fields in crop production burn it releases considerably more heat than fields that were planted with tillage.

Mature wheat forms a dry and continuous fuel that can easily catch on fire during harvest operations or from other human ignition sources. Wildfires burning in wheat can release a considerable amount of heat resulting in the removal of most soil organic matter. The loss of soil organic matter in agricultural fields following a wildfire can create negative impacts for soil structure and future crop production. Loss of soil organic matter from fires is closely linked to changes to soil physical and chemical properties (Mataix-Solera et al., 2011; Araya et al., 2016). Proper rehabilitation of burned fields is critical to reduce water and wind erosion. Research across Europe suggests that proper post fire soil erosion control practices could reduce impacts by 63-77% in the first year following a wildfire (Vieira et al., 2023). Land managers in the United States also try to mitigate the adverse effects of high-severity wildfires through post fire rehabilitation treatments (USDA Forest Service, 1995, 2000, 2002). Common treatments include contour tillage or felling, straw mulch, and vegetation seeding (Robichaud 2000).

Due to the increase in the frequency and size of wildfires burning agricultural fields, it is important to better understand the impacts of different rehabilitation practices. Common rehabilitation of burned rangelands and crop fields includes contour tillage, spraying for noxious weeds, seeding vegetation, and placement of straw or other erosion structures. Cover crops have also been proposed as one tool to help minimize erosion and increase organic matter. However, water use dynamics in a low rainfall, dryland production area are less understood. Initial research suggests that winter cover crops planted in the fall decrease soil moisture in low precipitation zones (Barroso et al., 2025). Following a devastating 2018 wildfire season in eastern Oregon many farmers planted winter wheat as a cover crop on severely burned wheat fields. Wheat cover crops were planted late in October into early November and then terminated in late May before additional water was used through the hot and dry summer months. The objective of this pilot study was to determine the impact of a wheat cover crop on soil moisture and soil nutrients as a potential post wildfire rehabilitation practice in dryland wheat production systems to better inform future research with a more robust and replicated experimental design.

Methods

Site Location

The Sunset Valley wildfire started July 1, 2021, outside of The Dalles in north central Oregon. The fire consumed around 1,000 acres of dryland wheat, rangeland, and pasture. Wheat fields were a week away from harvest and were fully consumed by the fire (Figure 1). A local wheat producer seeded a cover crop of winter wheat into a burned field in early November 2021. The soft white winter wheat variety LCS VooDoo was used. Seed was placed with a hoe drill with 20 lbs of nitrogen fertilizer per acre using liquid ammonium thiosulfate (12% nitrogen and 26% sulfur). The entire field was not seeded as the fire was successfully stopped with a disked fire break in one area of the field and the farmer also ran out of seed. This created a unique area to do a side-by-side comparison of areas burned and cover cropped, bare burned soil, and non-burned fallow areas that were not seeded. The producer terminated the winter wheat cover crop in late May 2022 using glyphosate herbicide. Soils are a Walla Walla silt loam in a 12-inch precipitation zone with hot and dry summers (Figures 2 and 3).



Figure 1. Burned pasture and wheat field outside of The Dalles, OR on August 2 after it was burned during the Sunset Valley wildfire on July 1.

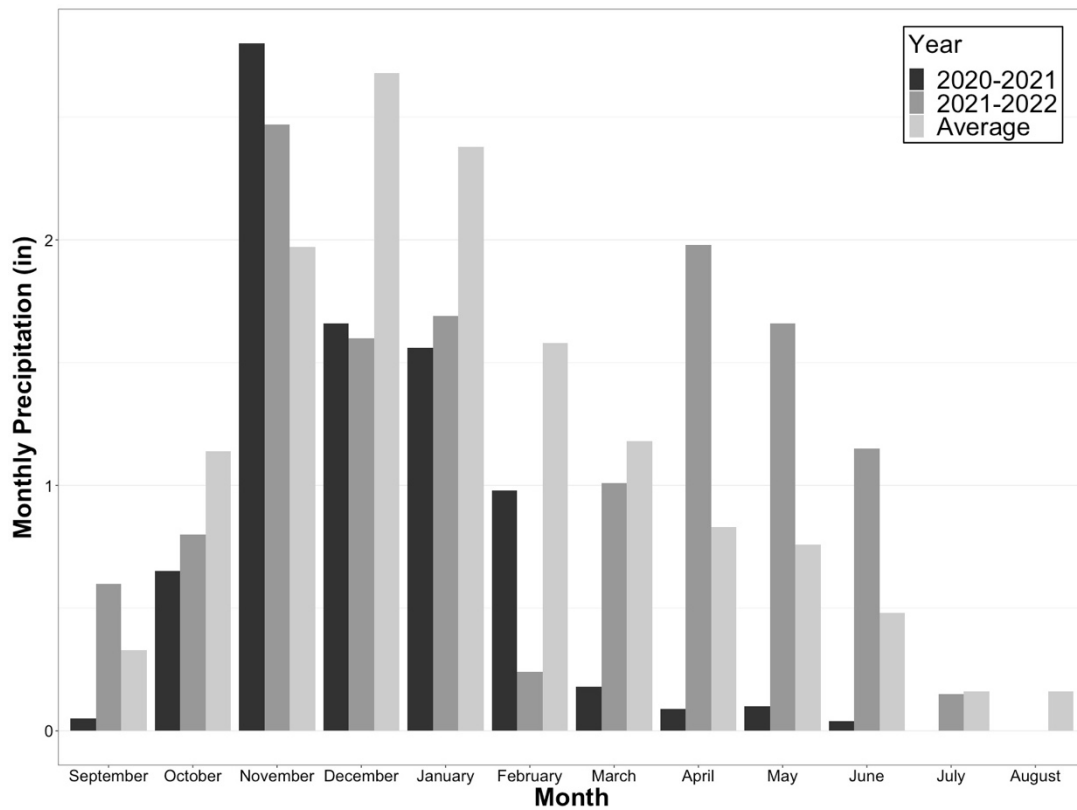


Figure 2. Monthly rainfall during 2021, 2022, and long-term average as recorded at the Columbia Gorge Regional Airport in Dallesport, WA, 5 miles north of the study site.

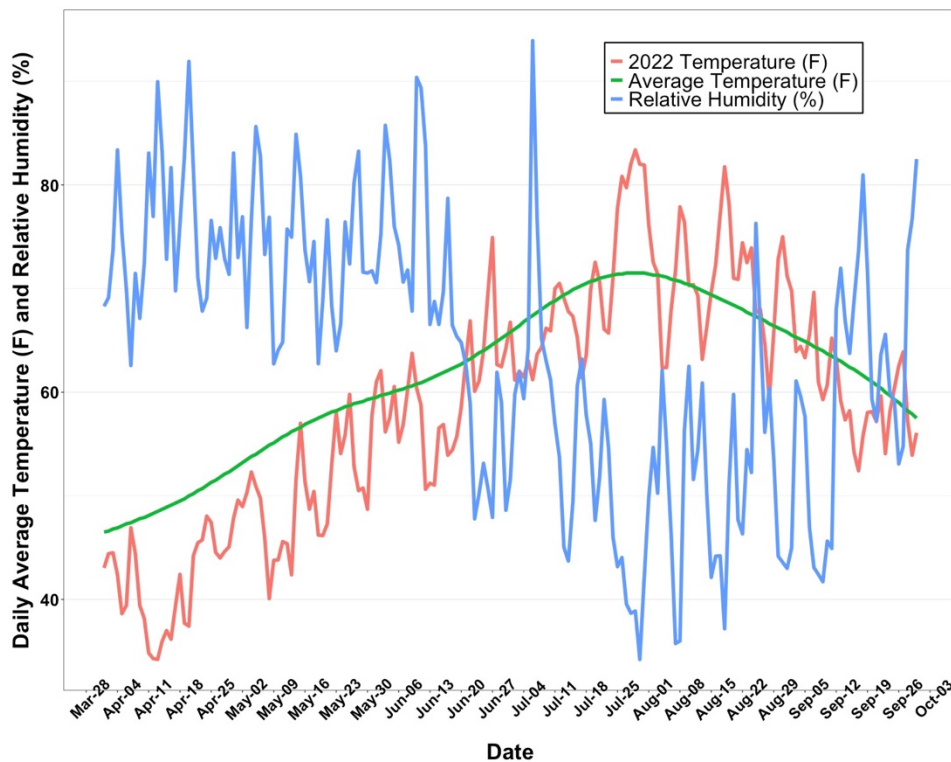


Figure 3. Daily temperature with humidity from end of March through end of September, 2022 as recorded at the Columbia Gorge Regional Airport in Dallesport, WA, 5 miles north of the study site.

Data Collection

Cover of the different treatments was visually estimated following cover crop termination. Soil probes were placed in mid-May prior to cover crop termination and continued to monitor soil moisture through early September (Figure 4). A Decagon Em50 data logger system with ECH₂O EC-5 moisture sensors was used to record soil moisture. A single sensor was placed at each tested depth in each treatment for a total of 5 sensors connected to two different data logger recording stations. Sensors were buried 6 inches in the non-burned fallow, burned and cover cropped, and burned parts of the field. Additional sensors were placed 12 inches down in the soil in the burned and covered, and bare burned areas to better compare those treatments. The covered and fallowed parts of the field were large (greater than 2 acres), while the burned and uncovered area was a narrow strip measuring 50 ft by 300 ft. Each probe was placed at least 30 feet apart from each treatment along a flat bench in the field. Soil samples were taken on August 8, 2022 to compare soil moisture and soil nutrients from 0-6 inches and from 6-12 inches. Soil nutrients tested include nitrate nitrogen, ammonium nitrogen, phosphorus, potassium, and sulfur. Organic matter and pH were also tested. Eight



Figure 4. Placement of soil moisture probes in burned wheat field in May 2022. Notice cover crop planted to the left. Non-burned fallowed area is to the right and out of the camera frame.

different soil samples were taken for each depth, within each treatment, and mixed to form a composite sample that was sent to a lab for analysis. As this was a basic pilot study, inferential statistical analyses were not completed as treatments were not replicated due to limited size of the comparison region.

Results

Cover of the different treatments was 50% for the burned and covered area, 0% for the burned and uncovered area, and 60% in the unburned fallow part of the field. Moisture probes indicated a sharp decline in soil moisture in late May following cover crop termination (vertical dotted line on Figure 5). The top 6 inches in the uncovered burned area also declined in that period, but to a lesser degree. Soil moisture in the top 6

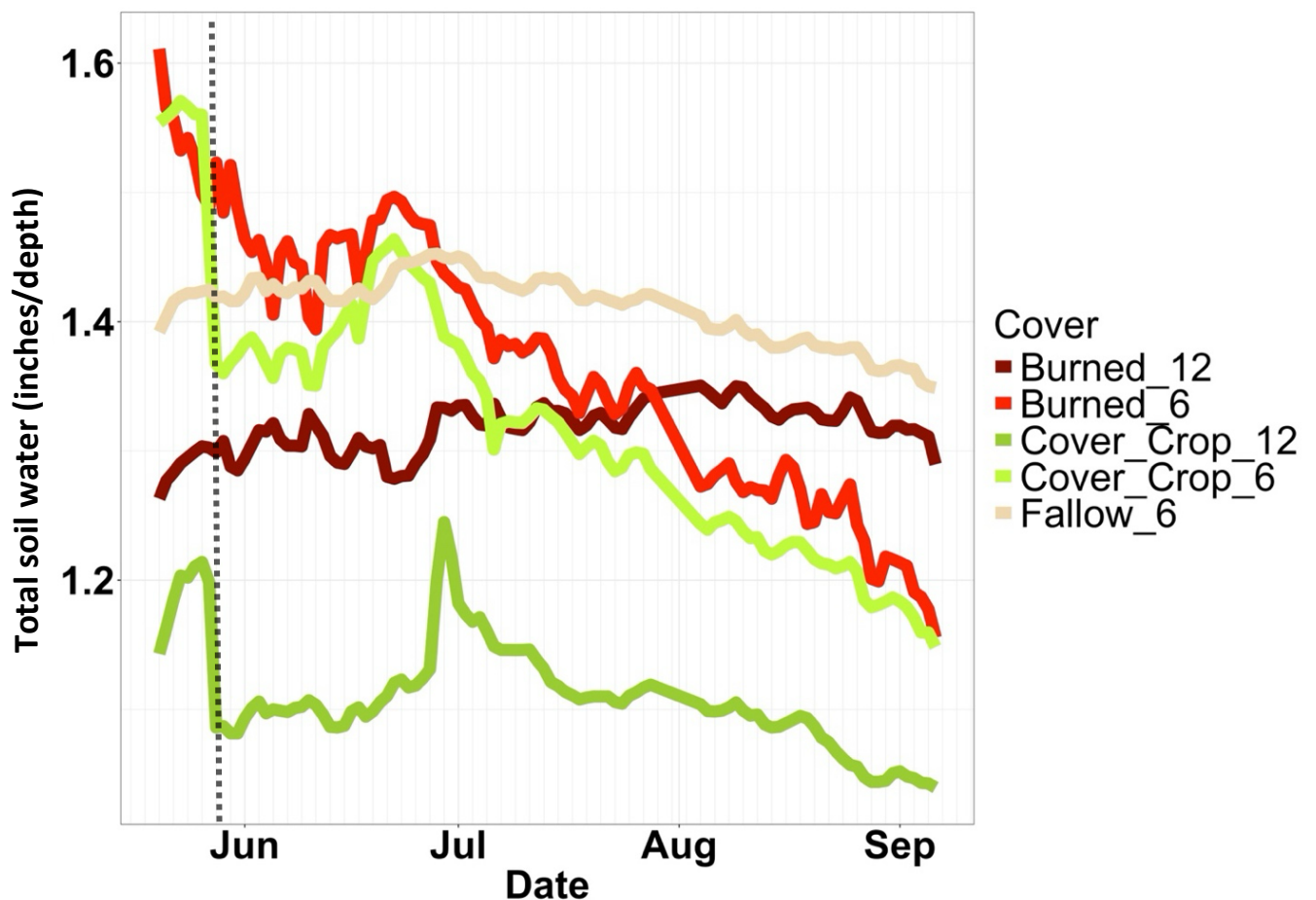


Figure 5. Soil moisture in inches per depth recorded with soil moisture sensors buried at 6 and 12 inches in burned wheat field in 2022. Treatments included a non-burned fallow part of the field, burned and bare area, and burned area planted with a wheat cover crop.

inches stayed similar between the cover cropped and non-covered burned areas, however both declined below levels in the non-burned fallow part of the field in early July. Lower down in the soil from 6 to 12 inches moisture was lower in the cover cropped areas compared to non-covered burned areas, but only by about 0.2 inches of soil water. Soil samples taken in the first week of August also support soil moisture levels recorded by the moisture sensors, though indicate higher moisture in the non-burned fallowed areas (Figure 6). Organic matter was increased by almost 0.5% for the cover cropped soils at both depths compared to areas burned without a cover crop (Figure 7). Nitrate nitrogen was increased in the top 6 inches in the burn where no cover crop was used and similar in the cover crop and unburned areas (Figure 8). However, from 6 to 12 inches

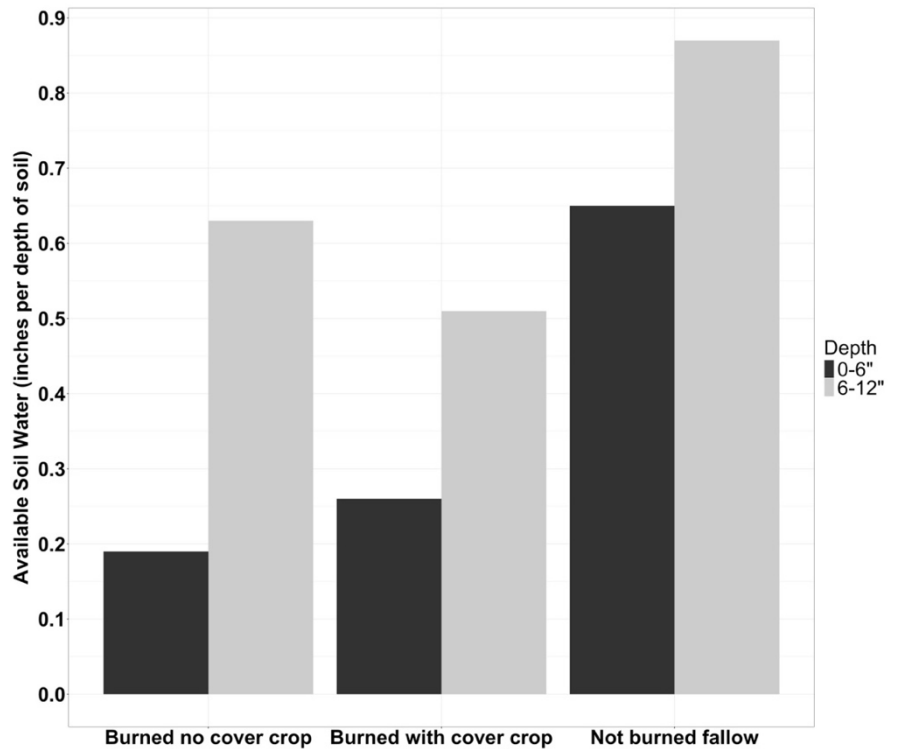


Figure 6. Soil moisture in inches per depth in soil samples taken in early August 2022.

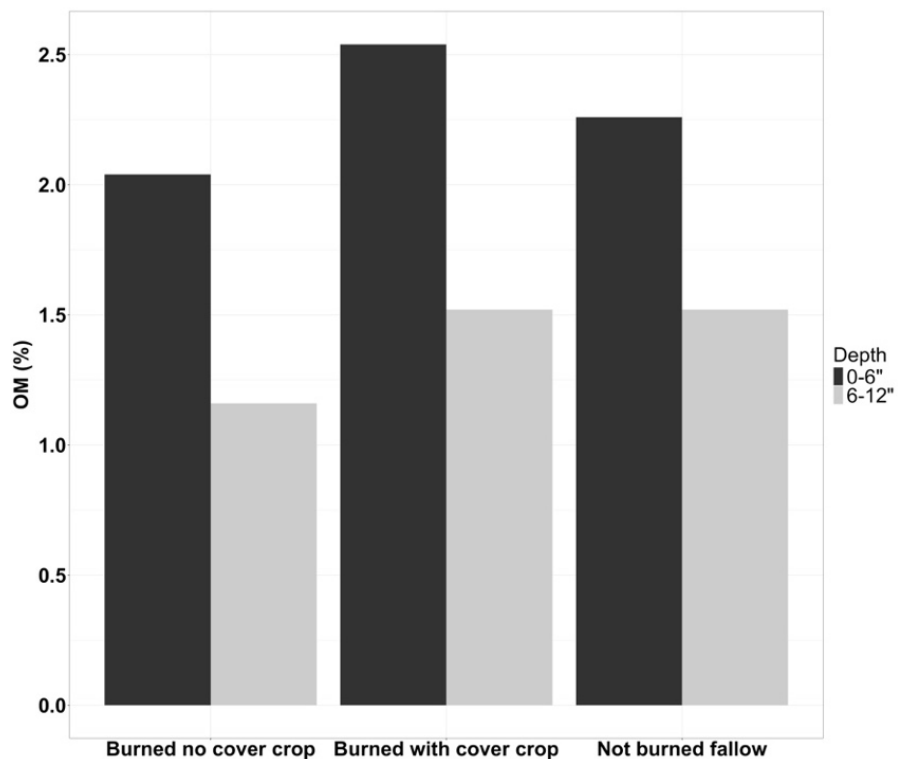


Figure 7. Soil organic matter (OM) % in soil samples taken in early August 2022.

nitrate nitrogen was similarly lowered in burned soils compared to unburned. The unburned fallow areas of the field were similar to the cover cropped areas except for organic matter being slightly lower in the top 6 inches. Soil ammonium nitrogen and other examined nutrients varied little between the different treatments.

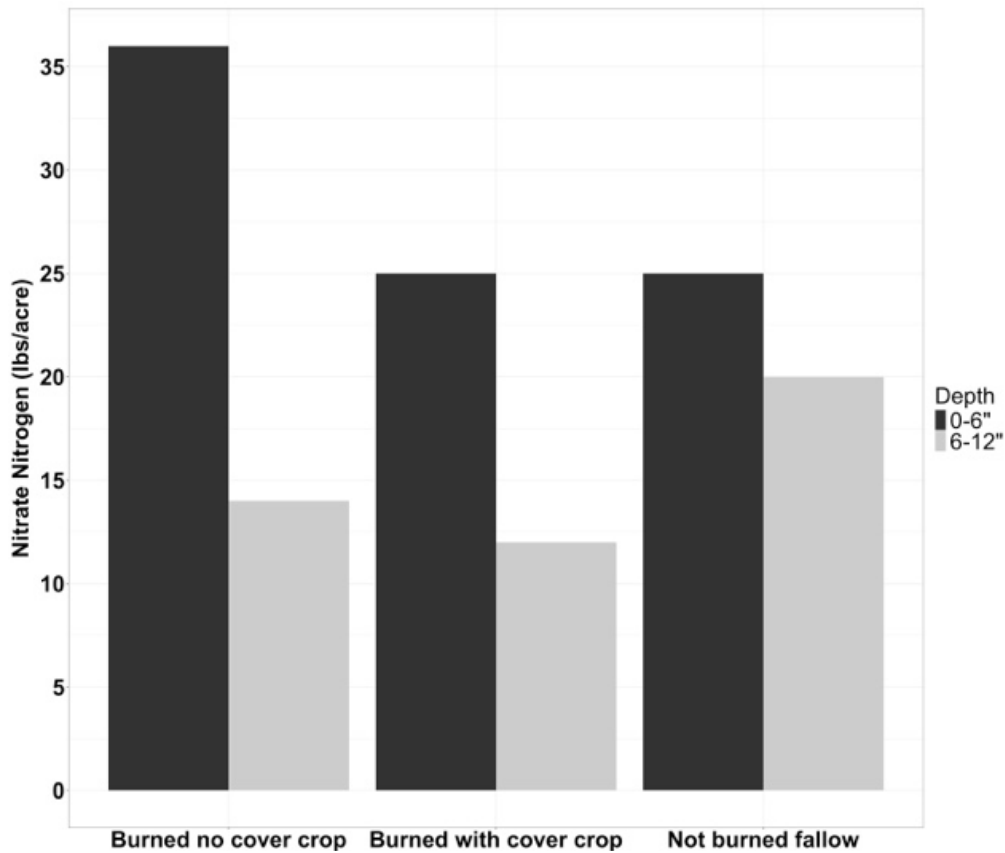


Figure 8. Nitrate nitrogen levels in soil samples taken in early August 2022.

Discussion

Overall soil moisture was similar in the top 6 inches for cover cropped and bare areas of the burned wheat field. However, from 6 to 12 inches in the soil profile, the cover crop reduced soil moisture. Prior to termination the cover cropped area had lower moisture than the bare area of the field from 6 to 12 inches, likely as the cover crop was using moisture to grow. However, after cover crop termination it dropped even lower compared to the bare area. This is likely due to no longer having living roots in the cover cropped areas pulling up moisture from lower in the soil profile. A similar drop happened for the cover cropped areas in the top 6 inches following termination. Little rainfall was

recorded during that time so there was no additional moisture to increase soil moisture until later in late June. The drop in moisture following termination could also be due to the low organic matter in the soil and the presence of dead vegetation helping to wick moisture to the soil surface and transpire out of the cover cropped areas.

Additional studies should examine how water infiltration rates compare for the treatments as most precipitation starts in the late fall after the soil probes were removed. In Texas, a study found that a warm-season cover-crop mix lowered stored soil water by 22–26% at termination, but post-termination infiltration was 2 to 4 times greater than fallow (Mubvumba et al., 2021). This suggests that though the cover crop used more moisture, it may help increase soil infiltration rates later in the fall once rainfall returns and boost water recharge for the future cash crop. Often wildfires will cause hydrophobicity issues in soils in similar Mediterranean climates and thus ways to increase infiltration are critical (Hubbert et al., 2006). Soil moisture spiked at the end of June for all treatments, except for the burned areas at 6 inches, which corresponded with a rainfall event. Figures 2 and 3 indicate rainfall above average for June and a spike in humidity that corresponds with the spike in soil moisture. This spike was most noticeable in the burned and covered treatment at 6 to 12 inches in the soil profile, indicating that the cover crop may have increased soil infiltration. However, this increase was short lived, again possibly from increased transpiration out of the cover cropped soils.

Soil moisture also decreased in both burned areas compared to the unburned areas in both the top 6 inches and from 6 to 12 inches. This indicates that wildfires can remove a substantial amount of water from the soil profile for future crops. The use of a cover crop may help enhance soil infiltration and help the water holding capacity catch up. Organic matter was lower in the burned and bare treatment compared to the non-burned fallow, and burned and covered areas. Similar to the impact of this wildfire on soil organic matter, previous research has established that prescribed burns to remove crop residue from wheat fields also removes a significant amount of organic matter (Al-Hedny et al., 2025; Tawfeeq et al., 2025). It is surprising that the burned area did not

have lower organic matter compared to the non-burned treatment. The soil had over a year to recover, but this is a relative short period for soils. The cover crop successfully increased soil organic matter in the top 6 inches compared to the other treatments and was similar with the non-burned areas from 6 to 12 inches. This increase in soil organic matter should also help increase soil water holding capacity, recharging the soil moisture after a severe wildfire has lowered it.

Changes in soil nitrate nitrogen levels appeared to be mainly in the top 6 inches. Due to lower than average winter and spring precipitation, these elevated levels were likely not seen in the 6 to 12 inch zone of the soil. Ammonium nitrogen is more tied up in the soil and it is not a surprise that large differences were not observed. Nitrate nitrogen levels may have been lower in the cover cropped area as the wheat was using it. Overall, the spike in nitrate nitrogen suggests that farmers seeding in an emergency cover crop should not apply much nitrogen fertilizer as the fire may increase nitrogen availability.

This study is full of limitations as treatments were not replicated due to limited suitable area for side-by-side comparisons. Fire rehabilitation research is challenging due to limited control of where a fire occurs, having comparable treatments within short proximity, and having funding and interest to use cover crops. Fortunately, in this study, all three occurred making this initial pilot study feasible. The data collected are a useful framework in guiding future research. A more robust experimental design and integration of multiple years and locations would provide more evidence on which to draw stronger conclusions to guide management decisions. In the future, researchers should pair with local conservation agencies, such as soil and water conservation districts and USDA NRCS to conduct research to better understand the management implications of conservation practices when cost share dollars are being used to help landowners implement rehabilitation practices.

Conclusion

The cover crop used about the same amount of water as the burned areas without a cover crop in the top 6 inches. From 6 to 12 inches, the cover crop did result in slightly lower

soil moisture when compared to the area without any cover. Despite the lower soil moisture at the lower soil depth, the winter wheat cover crop increased soil organic matter and may possibly help future cash crops have more water to utilize through higher infiltration rates and water holding capacity. Additional research is clearly needed to examine infiltration rates in burned fields with and without cover crops planted. It would also be beneficial to examine soil moisture trends across a summer for cover crops that are not terminated. Cover crops in the region are often terminated by June 1st to avoid complications with crop insurance though (Park et al., 2023). This study supports that the end of May appears to be a good time for termination as soil moisture stayed somewhat similar between the treatments. The roots and residue remaining after the crop was terminated continued to contribute to soil organic matter and little wind or water erosion was observed during the duration of this study. Wheat appears to be a good cover crop to utilize for ground stabilization in burned fields in the region as it established quickly and provided 50% ground cover to protect soil.

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