Improving Frost Seeding Accuracy with an Entry Level GPS Unit

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Abstract. Guidance utilizing GPS has long been used for various operations in row crop agriculture. However, the high cost of these systems has limited their use in low-input forage and livestock operations. Reduced prices and the availability of used guidance systems have the potential to increase the use of precision agriculture in pastoral settings. In the past, frost seeding often resulted in areas that received no seed and areas that were double seeded. The objective of this experiment was to evaluate the impact of using a guidance system on the uniformity of seed dispersal. This study was conducted at the University of Kentucky's Research and Education Center, located in Princeton, KY, USA in 2019 and 2021. The experimental design was a randomized complete block with four replications. Four pastures ranging from 2.5 to 4.3 ha were mock seeded using a UTV equipped with GPS guidance technology. The guidance system was initiated, but covered with an opaque bag, and the four pastures were driven by sight alone. This mock seeding process was then repeated utilizing the guidance system. Frost seeding without GPS guidance resulted in a 49% and 21% overlap in 2019 and 2021, respectively. At an overseeding cost of $89/ha and an average overlap of 35%, the cost of a guidance system could be recouped in as little as 48 ha. The results of this study indicate that GPS guidance systems have the potential to improve the uniformity of seed dispersal, thus reducing the cost of frost seeding for producers.

Introduction

Frost seeding is the practice of overseeding, particularly legumes other than alfalfa, into an existing grass stand in the early spring when overnight temperatures are still dipping below freezing. Rising temperatures during the day thaw out water in the top layer of soil, which then freezes again overnight. The action of repeated freezing and thawing creates openings in the ground, which cover the seeds in a thin layer of soil. This may be a good practice for producers looking to renovate a pasture with the addition of legumes, or to simply fill any bare spots in a pasture that may have been overgrazed or sprayed for weeds. This practice is done in many low-input, livestock-based operations that do not currently utilize the GPS technology traditionally seen in row-crop agriculture. In this paper, we present results from a mock seeding experiment conducted by two different drivers across four unique pastures. We hypothesize that incorporating GPS guidance would increase the uniformity of seed dispersal, and this experiment sought to quantify the potential impacts.

Methods and Study Site

An experiment evaluating the impact of GPS guidance on the uniformity of seed dispersal during frost seeding was conducted at the University of Kentucky Research and Education Center located in Princeton, KY, USA (37°6'1" N, 87°51'22" W). This experiment was originally conducted in 2019 and then repeated in 2021, with a different operator each year. The experimental design was a randomized complete block with four replications. The four replications consisted of four pastures ranging in size from 2.5 to 4.3 ha. These pastures were mock seeded, with and without GPS guidance (Raven Cruizer II GPS, Raven Industries, Sioux Falls, SD) using a Kawasaki Mule UTV. The simulated spreading width was 9.1 m, and the target ground speed was 16 km/h. For the unguided portions, operators started the GPS unit to track and record the movement of the UTV, but then covered the screen with an opaque bag so that guidance could not be utilized. For the guided portion, operators returned to their starting point. The same process was repeated, but this time the screen remained uncovered and GPS guidance was followed. The entire procedure was repeated for each of the remaining three pastures. The data recorded by the GPS unit was mapped and analyzed to determine speed and percentage of both missed and

overlapped areas. Data from both trials were analyzed using the general linear model procedure (SAS, Cary, NC). For this study, a P-value of 0.10 was used.

Results and Discussion

Uniformity of Seed Dispersal

Frost seeding without GPS guidance resulted in 49% overlap in 2019, and a 21% overlap in 2021 (Table 1). This clearly indicates that the tendency of the drivers was to overlap, rather than to have any skips. When GPS guidance was utilized, overlaps were lowered to 3 and 4% in 2019 and 2021, respectively. This would reduce seed cost and fuel usage by approximately one-third, but more importantly reduce wasted operator time. Small portable GPS guidance systems have not only become user-friendly, often taking 10 minutes or less or hook up, but also more affordably priced.

Results from GPS Guidance Frost Seeding Experiment				
Guidance	2019		2021	
	Overlap (%)	**Missed (%)**	**Overlap (%)**	**Missed (%)**
Unguided	49.8	14.0	21.2	15.6
Guided	3.0	10.0	3.6	10.0
P-value	*0.09*	*0.49*	*<0.01*	*0.04*

Table 1. The percent of overlapped and missed area for guided and unguided repetitions, as well as their corresponding P-values for both trials in the experiment.

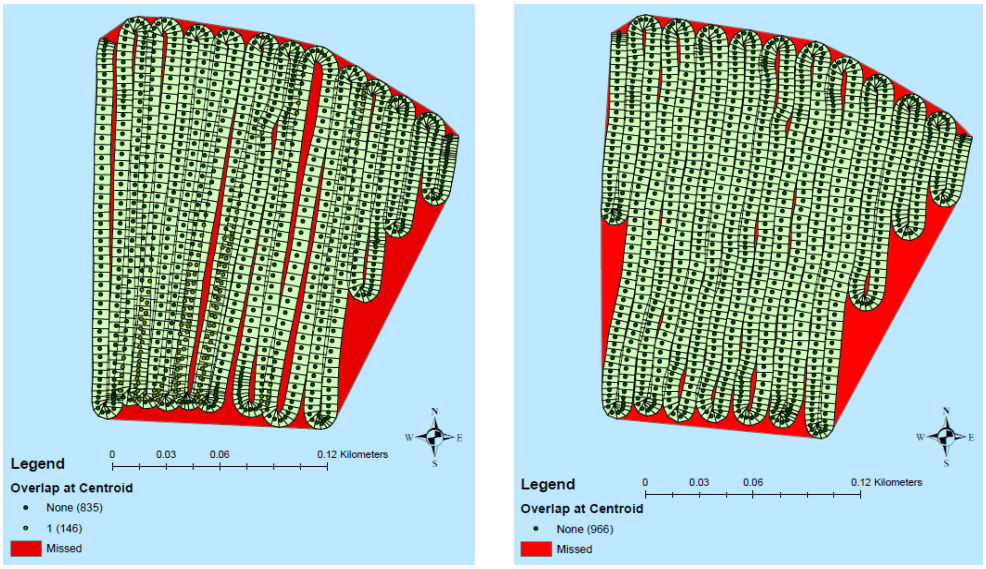

Figure 1. Maps of a pasture from the 2021 trial driven unguided (left) and guided (right). Any missed areas are highlighted in red.

While the operators generally had a tendency towards overlap, there was also a higher percentage of missed areas in the unguided repetitions than in the guided. At an average of 15% missed area without guidance, this means that approximately 7.5 out of 50 ha of pasture would go without any seed at all. Missed areas could equate to lower pasture production via decreased nitrogen fixation from legumes and potentially higher levels of weed encroachment. Another benefit of the GPS guidance systems is that they provide the operator with an estimate of ground speed, which is something not available on many UTVs. This can greatly improve seeding accuracy since driving too slowly wastes seed, while driving too quickly may not spread enough seed onto the field.

Financial Advantages

At an average overlap of 35% without guidance, and an average total frost seeding cost of $89/ha, a producer could spend around $1,557 in unnecessary seeding expenses each spring across 50 ha of pasture. The net result is that the cost of the guidance systems ($1,500) could be recouped in as little as 48 ha. Table 2 outlines the number of ha needed for a farmer to recoup the full cost of a $1,500 guidance system, based on driving accuracy and application input costs. Since GPS systems are so versatile, they could be used for other field operations such as spreading fertilizer, spraying herbicides, and no-till seeding. When the guidance system is used for multiple field operations, the cost be recouped at an even faster rate.

Acres Required to Recoup the Cost of a Guidance System							
Cost of Operation		Amount of Overlap (%)					
		10	20	30	40	50	60
Operating Costs ($/ha)	40	375	188	125	94	75	63
	50	300	150	100	75	60	50
	60	250	125	83	63	50	42
	70	214	107	71	54	43	36
	80	188	94	63	47	38	31
	90	167	83	56	42	33	28
	100	150	75	50	38	30	25
	110	136	68	45	34	27	23
	120	125	63	42	31	25	21

Table 2. The ha requirement that a producer would need to cover to recoup a GPS guidance system cost of $1,500, based on the amount of driver overlap and application input costs.

Time savings

Tendency towards overlap means that taking advantage of GPS guidance technology will also save producers time out in the field. This point is particularly persuasive when looking at Figure 2 which shows the map of one of the unguided versus guided repetitions in trial one. At an average speed of 14.5 km/h and an average overlap of 35% without utilizing GPS guidance, frost seeding would take approximately 72 minutes longer for 50 ha of pasture, using a spinner seeder with a 10-meter spread.

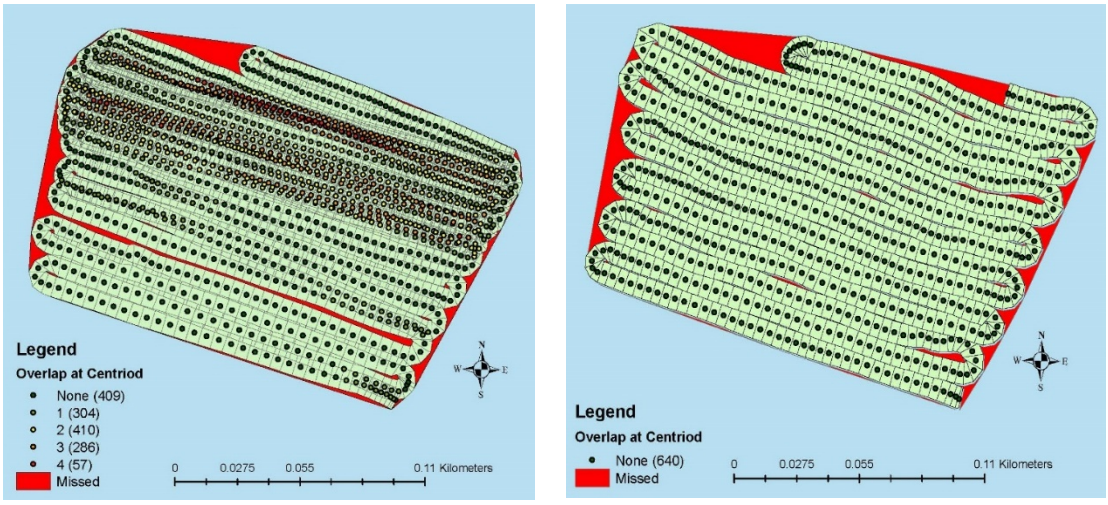

Figure 2. Maps of a pasture from the 2019 trial driven unguided (left) and guided (right), highlighting the driver tendency towards overlapping.

Conclusions

Rising input and operating costs demand that even more extensive pastoral systems improve efficiency. Utilizing a GPS guidance system greatly reduced the amount of driver overlap and missed areas when frost seeding. While some farmers may initially balk at the idea using GPS guidance due to a high initial investment cost, the results of this experiment clearly indicate capital expenses could be recouped in as little as one year. This experiment should be repeated with additional drivers to get a more robust dataset.

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