Title: Equipment matching for reduced traffic in alfalfa and grass silage production

PI, Co-PIs, Authors:

Matthew Digman, Andrew Lamberson

Address: 410 S. 3rd Street; River Falls, WI 54022
Phone: 715-425-3975
Email: matthew.digman@uwrf.edu

Abstract:

Forage yield and quality is suppressed by machine traffic during harvesting operations. However, little attempt has been made to reduce this loss by managing traffic in mid-western alfalfa and grass fields. Recent developments in large forage harvesters and vehicle guidance merit taking a closer look at equipment matching as a way to employ controlled traffic farming (CTF). Large forage harvesters allow wide areas of the field to be merged so as to maximize harvester capacity. This ultimately reduces the field traffic and would allow adoption of wider traffic lanes, maximizing CTF's impact on forage yield. Vehicle guidance (i.e., auto-steer) systems are becoming more common for field operations such as mowing, seeding and fertilizer application and could be used to maintain permanent traffic lanes between cutting and harvest seasons.

Although adoption of these technologies has put controlled traffic within reach, significant challenges remain. One of these challenges is matching equipment widths for multiple field operations. Past work has shown that the economic benefit of establishing a controlled traffic strategy is dependent on investment in equipment. To address this challenge, we developed a spreadsheet-tool that would allow producers to explore the opportunities for controlled traffic in their current machinery fleets.

Introduction:

Researchers have observed that over 60% of a field may be trafficked during a single harvest (Kroulik et al., 2014). Field traffic not only leads to soil compaction but also damages regrowth of the plant (Schmierer et al., 2004). Alfalfa yield is suppressed when damaged shoots are replaced at the expense of plant root carbohydrate stores (Sheesley et. al., 1982). Additionally, the damaged plant tissues can also serve as entry points for plant pathogens. Although compaction is a secondary factor in cutting-to-cutting yield differences, it impacts ground water infiltration and has been attributed to several plant diseases. Quantitative assessments of the impact of traffic on both grass and alfalfa yield range from 4 to 22% depending on the timing of the traffic event (Schmierer et al., 2004; Jorgensen et al., 2009).

Controlled traffic farming (CTF) has been utilized in cereal grain, corn and, more recently, grass production to reduce the impact of machine traffic on crop yields (Hargreaves, 2017). The concept is simple: match machinery widths so that permanent traffic lanes can be established on lands of the field (Figure 1). Headlands serve as turning areas where vehicles and implements of varied turning radii may not be able to overlap wheel tracks. It is important that each field operation maintains the same traffic lanes and, as such, precision agriculture has been employed to align various field operations for each cutting. Studies in northern Europe have demonstrated that equipment can be matched on 8, 9 and 12-m working widths, reducing trafficked area to about 21, 20.5 and 17%, respectively. In Hargreaves' (2017) study, perennial ryegrass yields have been observed to improve 12% after only one year of CTF. Studies have also been conducted in ryegrass, red clover and grass-clover mixtures with similar or better results. Furthermore, economic analyses have indicated higher profitability for CTF systems compared to random traffic; however, these gains are sensitive to the initial equipment investment and farm size.

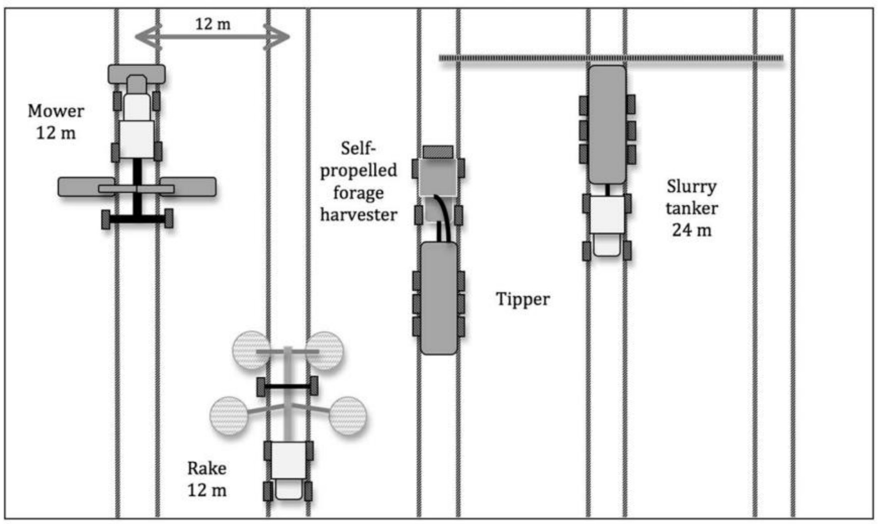

Figure 1. Example of a 12-m controlled-traffic farming system for silage (Hargreaves, 2017).

Considering that CTF systems are sensitive to equipment investment, it is important for the producer to know which machines in their fleet can be utilized to reduce field traffic. That is, which permanent lane width can their machinery system already support; which machines need to be replaced or modified; and, which machines are limiting track width and resulting percentage of the field trafficked. Furthermore, it would be beneficial to look the impact that field shape and size have on area traffic for a given machinery complement.

Materials and Methods:

The first task was to establish working and track width, tire size, and weight for the range of equipment utilized in silage production. In some cases, this information could be gleaned from the manufacturer's website or marketing literature, but in many cases these data needed to be captured by taking measurements in the field.

Both manufacturer and field data were summarized into a spreadsheet tool to aid producers in purchasing complementary equipment or to explore track widths for existing equipment fleets, and to estimate area trafficked.

Results and Discussion:

Data were collected from a multitude of drills, seeders, fertilizer spreaders, mounted and self-propelled mowers, rakes, tedders, mergers, self-propelled harvesters, and tractor- and semi-towed trailers. These data were gleaned from marketing literature and from observation on dealership lots. Machine specifications were organized into a spreadsheet so the producer could find their machine. A partial record of these data is presented in Table 1.

Table 1. Implement working, track and tire width database.

Operation	Make	Model	Working width (ft)	Track width (ft)	Tire width (ft)
Seeding	John Deere	BD1113	13.0	14.3	0.6
Seeding	Great Plains	1206 NT	12.0	14.8	1.0
Seeding	Great Plains	1300	13.0	14.4	0.6
Spraying	John Deere	4830	100.0	10.1	1.3
Spraying	John Deere	4730	100.0	10.1	1.3

The machine data could then be utilized in conjunction with a spreadsheet-based calculator to determine the number of unique traffic lanes and the percent of the field that was trafficked (Table 2). The green area of the sheet allows a producer to enter up to ten field operations including machine make and model, and working, track and tire width. The largest working width machine determines the working region.

For subsequent machines, the tracks are placed considering the working width and track width. The tool assumes that the tractor has been adjusted to track within the track width of the trailed machine or offset one track width in a laterally-pulled machine. This would be best practice in a controlled traffic system. If this is not the case, the tractor could be added as a separate entry.

Table 2. Worksheet to determine unique traffic lanes and trafficked area per widest working pass.

Pass	Operation	Make	Model	Working width (ft)	Track width (ft)	Tire width (ft)		Passes	Track 1		Track 2		Track 3		Track 4	
1	Mowing	Deere	W155	15	12	1.00		4	46.5	58.5	31.5	43.5	16.5	28.5	1.5	13.5
2	Merging	Oxbo	334	30	8.5	1.00		2	40.75	49.25	10.75	19.25				
3	Harvesting	Claas	890	60	8.5	2.67		1	25.75	34.25						
4								0								
5								0								
6								0								
7								0								
8								0								
9								0								
10								0								
												Unique traffic lanes				14
									Trafficked area per widest working pass							36%

After each field operation has been entered, the spreadsheet automatically computes the number of unique (non-overlapping) tracks made in the region. The track width is determined as an average of the tire widths reported. Finally, the tool determines the percent of area trafficked as quotient of the average track width and the width of the working region. This calculation does not take into consideration headland area trafficked, but it will be also difficult to control traffic in those regions in practice. Finally, the spreadsheet tool allows up to four traffic lanes in the widest pass, beyond that the tool produces an error message.

When all data have been entered, the spreadsheet generates a plot of the widest working width (green line) and the traffic lanes (dashed line) (Figure 1). In the scenario plotted, the largest working width was 60 ft and the smallest was 15 ft. Fourteen traffic lanes were needed and 36% of the field pass was trafficked.

Figure 1. Traffic passes per largest working width (ft)

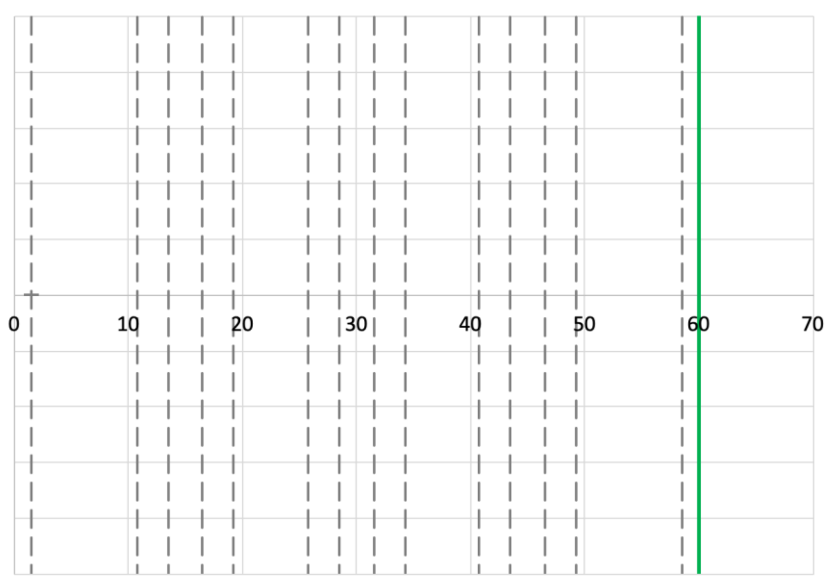

Table 1. Implement working, track and tire width database.

Operation	Make	Model	Working width (ft)	Track width (ft)	Tire width (ft)
Seeding	John Deere	BD1113	13.0	14.3	0.6
Seeding	Great Plains	1206 NT	12.0	14.8	1.0
Seeding	Great Plains	1300	13.0	14.4	0.6
Spraying	John Deere	4830	100.0	10.1	1.3
Spraying	John Deere	4730	100.0	10.1	1.3
Spraying	John Deere	4030	90.0	10.1	1.3
Spraying	John Deere	4030	100.0	10.1	1.3
Spraying	John Deere	4030	120.0	10.1	1.3
Spraying	John Deere	R4045	90.0	10.1	1.3
Spraying	John Deere	R4045	100.0	10.1	1.3
Spraying	John Deere	R4045	120.0	10.1	1.3
Spraying	John Deere	R4038	90.0	9.8	1.3
Spraying	John Deere	R4038	100.0	9.8	1.3
Spraying	John Deere	R4038	120.0	9.8	1.3
Spraying	John Deere	R4038	132.0	9.8	1.3
Spraying	Hagie	STS12	90.0	11.0	1.9
Spraying	Hagie	STS12	100.0	11.0	1.9
Spraying	Hagie	STS12	132.0	11.0	1.9
Cutting	John Deere	835	11.5	9.4	1.1
Cutting	John Deere	946	13.0	11.8	1.0
Cutting	Case iH	DC 133	13.0	10.9	1.0
Cutting	New Holland	1411	10.3	8.5	0.9
Cutting	New Holland	1431	13.0	11.3	1.1
Cutting	New Holland	210	9.2	8.6	0.9

Cutting	New Holland	310	10.3	8.5	1.2
Cutting	New Holland	313	13.1	10.8	1.0
Cutting	New Holland	H7230	9.2	8.6	0.9
Cutting	New Holland	H8080	13.0	10.9	2.0
Cutting	New Holland	H8080	15.4	10.9	2.0
Cutting	New Holland	H8080	18.0	10.9	2.0
Cutting	New Holland	H8080	19.3	10.9	2.0
Cutting	John Deere	R450	16.0	10.8	1.6
Cutting	Case iH	WD2504	16.1	10.9	1.6
Cutting	Case iH	WD2505	19.1	10.9	1.6
Tedding	New Holland	3625 ProTed	24.9	8.1	10.0
Raking	Kuhn	GA 7501	24.4	7.3	0.9
Merging	H&S	TFM2135	35.0	9.9	1.4
Merging	Oxbo	2334	39.2	8.5	1.4
Merging	Oxbo	918	12.0	11.1	0.6
Merging	H&S	M9	18.0	11.3	0.6
Harvesting	John Deere	8600	90.0	10.1	2.6
Harvesting	Claas	890 Jaguar	90.0	8.2	2.6
Harvesting	Claas	960 Jaguar	90.0	8.5	3.0
Harvesting	Claas	930 Jaguar	90.0	8.5	3.0
Harvesting	Claas	950 Jaguar	90.0	8.2	2.3
Harvesting	Claas	970 Jaguar	90.0	8.5	3.0
Harvesting	Claas	960 Jaguar	90.0	8.2	2.3
Silage wagon	H&S	HD7+4		7.0	1.2
Silage wagon	H&S	Power box-18		7.0	1.2
Silage wagon	Meyer	4516		6.4	1.0
Silage wagon	Meyer	Rt 620		7.1	1.4
Silage wagon	Meyer	4516		6.3	1.0
Silage Trailer	Meyer	XT2200		7.0	1.8

Silage Trailer	Meyer	8126Rt	7.0	1.8
Silage Trailer	Meyer	RTx 224	7.0	1.8
Silage Trailer	Meyer	RT 620	6.8	1.4
Silage Trailer	Penta	DB50	7.5	2.8
Silage Trailer	Penta	DB60	7.9	2.6
Semi Trailer	Meyer	9136 Rt	6.5	1.8

Acknowledgements:

We appreciate the support of MFA for funding Mr. Lamberson's time to complete this project and the wiliness of Western Wisconsin dealerships to allow us to measure their equipment.

References:

Hargreaves, P.R., S. Peets, W. C. T. Chamen, D. R. White, P. A. Misiewicz and R. J. Godwin. 2017. Potential for Controlled Traffic Farming (CTF) in Grass Silage Production: Agronomics, system design and economics. *Advances in Animal Biosciences: Precision Agriculture (ECPA)*. 8:2, 776–781.

Jorgensen, R.N., Green, O., Kristensen, K., Gishum, R., C.G. Sorensen. 2009. Estimating impact on clover-grass yield caused by traffic intensities. Ed. C. Lokhorst and P. W. G. Groot Koerkamp. Precision livestock farming '09. *Wageningen Academic Publishers*, 143–147.

Kroulik, M., Misiewicz, P., Chyba, J., White, D. 2014. Field traffic intensity for forage harvesting in the UK. Harper Adams University Project Report 099.

Schmierer, J., D. Putnam, D. Undersander, J. Liu and H. Meister. 2004. Wheel traffic in alfalfa – What do we know? What can we do about it? In: *Proceedings, National Alfalfa Symposium*. San Diego, CA.

Sheesley, W.R., D.W. Grimes, W.D. McClellan, C.G. Summers, V. Marble. 1982. The Influence of Wheel Traffic on Yield and Stand Longevity in Alfalfa*. In 1982 California Alfalfa Symposium Proceedings*, UC Cooperative Extension, Davis, CA.