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Effectiveness and Cost Benefit Of Turn Compensation In Row Crop Planters

In the United States, farm expenditures have steadily risen in past years, with 2024 production expenses forecasted to be $455.1 billion, a 2.3% increase compared to 2023 (USDA-ERS, 2024). Fertilizer, pesticide, and seed costs per acre have each risen by 213%, 106%, 256% respectively while yield and corn prices have only increased by 21% and 91% respectively (Schnitkey and Sellars, 2016). Seeds constitute almost 20% of the agricultural inputs required for corn production (USDA-ERS, 2023). From 1996 to 2022, seed cost has risen by an average of 5% annually (USDA-ERS, 2022). With the continuous rise of input costs, it is crucial that operators utilize technology that can help them plant their fields faster and more efficiently to maintain profitability.

Utilize technology for sustainable farming

Currently, many growers have started utilizing wider row crop planters to cover more ground faster. These planters typically consist of 16 and 24 rows, which have widths of 40 and 60 feet respectively. Though these massive machines can cover large amounts of area, wider coverage can lead to seed placement issues, especially when planting around curves, contours, and other field obstacles. On curvilinear passes, the row units on the inside of the curve travel at slower speeds, and the ones on the outside of the curve travel at higher speeds. The magnitude of the speed differential for row units on the inside and outside of the toolbar increases with a decrease in the curve radius. The frequency of curvilinear travel instances primarily depends on field shape irregularity, conservation areas such as grassed waterways , planting along the terraces, and field obstacles, among others. The planting system implementing uniform seed meter speeds would invariably see a higher seeding rate for row units on the inside and lower for ones on the outside of a field curve. The areas where seed population is significantly lower than target could become a potential weed site due to lack of canopy. Areas of high plant population may see stunted plant growth due to competition for nutrients, moisture, sunlight, and other input for appropriate plant growth. Seeding rate errors have been associated with yield losses with a high correlation between plant density and corn yields (Miller et. al., 2012).

Accurate seed metering to optimize yield

The seed metering unit is the component of row crop planters that enables accurate seed singulation to establish the desired plant population. Achieving optimal seed distribution directly impacts crop establishment and yield. Two types of seed metering mechanisms typically used in planters are the mechanical and electrical drive systems. In recent years, the metering mechanism of many planters has transitioned from mechanically driven seed meters to electrically driven meters allowing for better control of the seed singulation operation. A mechanical seed

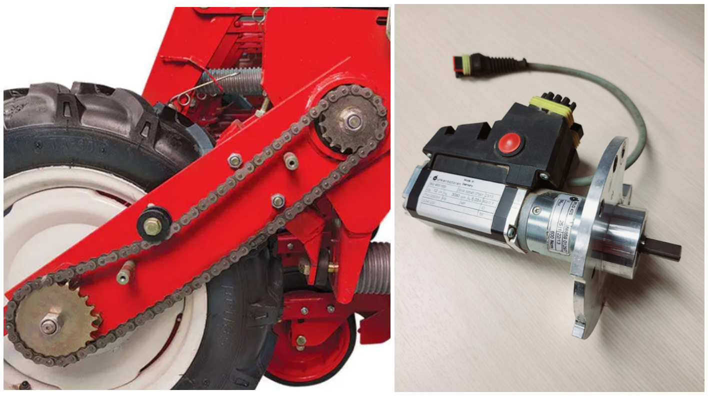

Figure 1. The (a) power transmission system assembly of a mechanical drive system (Kus, 2022) and the (b) DC motor of the electrical drive system.

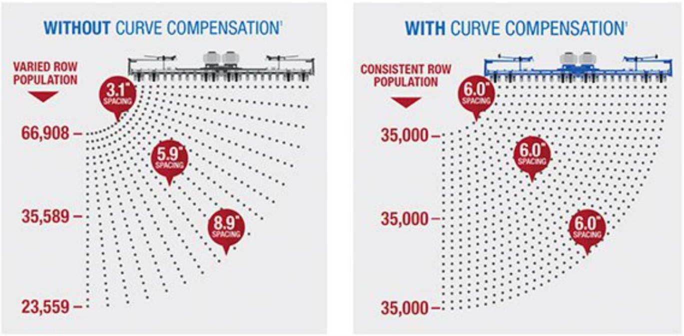

Figure 2. (a) Uneven seeding rate or population around curves when planting without turn compensation and (b) consistent seeding rate with the turn compensation (Kinze Manufacturing, 2024).

meter drive system connects driving tire motion to the seed meter through a chain and sprocket system (Fig 1a). With this system, seed metering accuracy is affected by tire inflation pressure, wheel slippage due to field conditions, and vibration due to field roughness. Poor planting quality is further amplified with increasing planting speed. An electrical drive system is simpler with significantly fewer parts, enabling easier maintenance. Its major component, an electric motor, allows control of each row unit (Fig. 1b).

This system makes it possible to manage the seeding rates of individual rows in areas within the field where population or speed changes occurs, making it ideal for variable rate seeding prescriptions and allow farmers to change rates on-the-go. Likewise, it allows the planter to maintain consistent population while making turns around field obstacles or contours. As a planter makes a curving turn, the outer radius of the outer end rows are under population target, and the inner radius rows are over population target. With electric drive meters, the system is able to adjust meter speed, allowing for the end row units to maintain the correct seeding rate regardless of being on the outside or inside of the turn. This technology feature is typically referred as turn compensation.

What is turn compensation?

To avoid overplanting on the inside rows and underplanting on the outside rows (Fig. 2a), the planter system continuously receives the speed signal of row units on each end and center of the toolbar. When a speed difference is detected between the right end row, middle row, and left end row, the turn compensation feature begins adjusting the electric drive meters to match the desired seeding rate and the speed differential of each row unit on the turn. The inner electric drive meters slow down while electric drive meters on the outer rows speed up to maintain the desired seeding rate (Fig. 2b). With turn compensation, the overall seeding rate across the field is consistent.

How effective is turn compensation during planting operations?

A study was conducted at Kansas State University wherein they developed a methodology to quantify turn compensation actuated on field with various acreage and varying boundary. The study examined eight production fields around Manhattan, Kansas, of varying shapes and sizes. Size of field ranged from 37 to 220 acres with average seeding rate of 28,000 seeds acre^{-1}. Turning radii within the fields were classified into extreme, medium , and straight passes to provide differentiation in varying magnitude of speed differential between the inside and outside of the toolbar (Table 1).

Table 1. The turning radii and its corresponding turn classification

Turning radius (m)	Turn classification	Expected speed differential
r < 20	Extreme turn	Turns with small radii resulting in over 85% speed increase from inner to outer row of the planter.
20 < r < 100	Medium turn	Turns just above the threshold for activating turn compensation to average sized turns with at least 25% speed increase from inner to outer row of planter
r > 100	Straight run	Any pass with no discernible turn that would enable turn compensation

After planting, turning radius around curves were determined using a GIS software. Random curves of varying turn classification were then selected. On each turn classification, plant spacing was measured along a 17.5-foot long strip on the inner, outer, and middle rows. This measured plant spacing is the actual plant spacing with the turn compensation actuated. This data was then used to calculate the expected plant population or seeding rate when planting without a turn compensation. Results showed that turn compensation was actuated for an average of 8.1%, or nearly 7.0 acres of the total average area of 95 acres of the fields examined. Of these turns, 7.1% (5.9 ac) consists of slight to medium turns, while 1.0% (0.9 ac) comprised extreme turns.

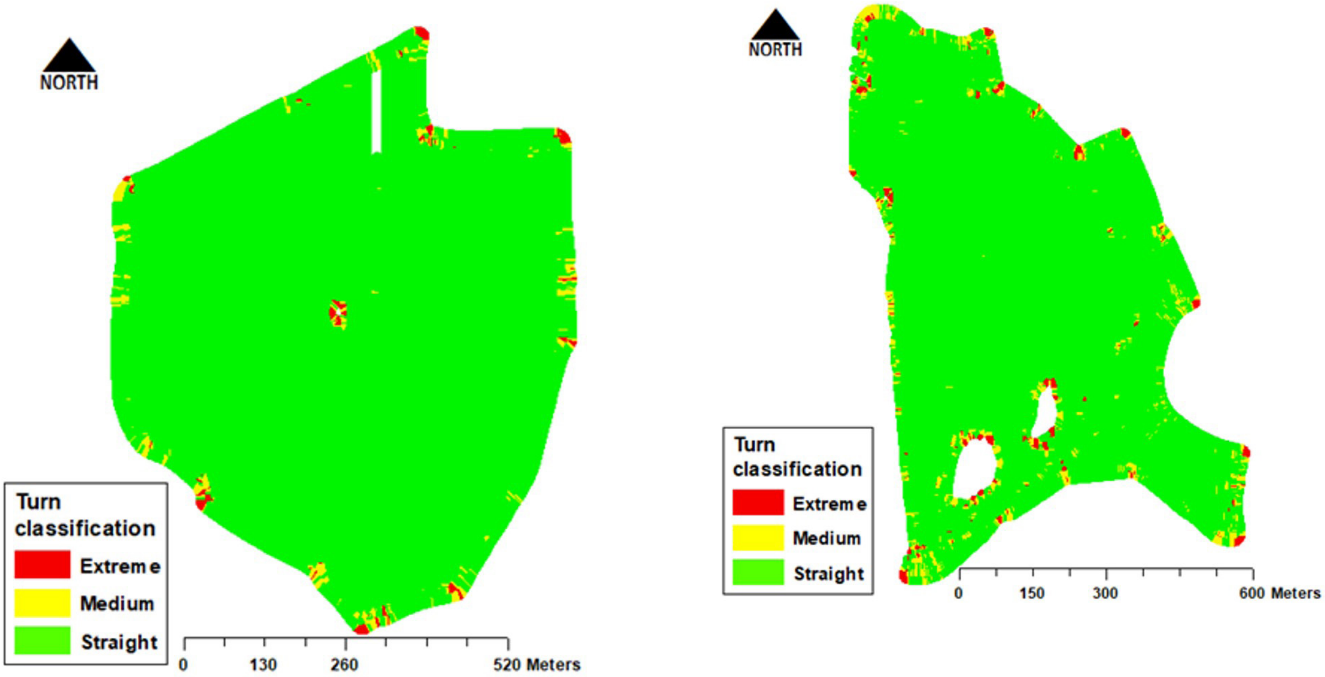

Figure 3. Two of the fields examined where (a, left) one field shows more straight boundaries and less obstacles and (b, right) another field with more irregularly shaped boundaries and obstacles.

Fields with more straight boundaries and fewer field obstacles (Fig. 3a) obtained fewer instances where turn compensation was actuated, with 5.2% of the total field area planted around curves, while fields with more irregularly shaped boundaries and obstacles (Fig. 3b) actuated the turn compensation for 11.3% of the total field area.

Measured plant spacing confirmed that planting without turn compensation will result in uneven plant spacing on both end rows of the planter. Plant spacing will be 44% narrower on the inside row and 31% wider on the outside rows around slight to medium turns, while navigating around extreme turns will result in 79% wider on the outside row and 44% narrower inside rows. Planting with turn compensation will significantly reduce the plant spacing variability. Plant spacing will be 6% narrower and 3% wider on the inside and outside rows, respectively. This will lead to consistent plant spacing on both end rows during turns. For example, if the target plant spacing was 8 inches, plant spacing on the outside rows will be 11.6 inches while inside rows will have plant spacing of 5.5 inches when planting without turn compensation around slight to medium turns. On extreme turns, higher variability will be expected. Plant spacing on the outside rows will be 14.3 inches while inside rows will have plant spacing of 4.5 inches. With turn compensation, plant spacing on the end rows will be 8.5 and 7.8 inches on the inside and outside rows, respectively.

This plant spacing variability is reduced with turn compensation when the end rows maintain seed spacing closer to the target seed spacing. Planting around slight to medium turns without turn compensation is expected to increase the seeding rate by 80.1% on the inside row and reduce by 30.9% on the outside row. Planting around extreme turns without turn compensation resulted in higher seeding rate error. The inside row can be over-planted by 570.1% more, while 42.5% fewer seeds may be planted on the outside row. With the turn compensation, the seeding rate error at any given scenario will be 5.3% and 1.2% on the inside and outside rows, respectively.

Cost benefit of turn compensation feature

Simple cost analysis associated with the potential savings on seed when using turn compensation indicated that planting around slight to medium turns will result in savings of \$11.4 acre^{-1} while outside rows will result in a loss of \$4.9 acre^{-1}. Conversely, savings and loss on extreme turns are estimated to be \$91.2 acre^{-1} and \$5.2 acre^{-1}, respectively. Such savings are related to fewer seeds planted on the inside rows while incurred loss is due to the extra seeds planted on outside rows when planting with turn compensation as compared to without it (Table 2).

Table 2. Cost benefit of using a turn compensation on a planter

Description	Turn classification	Average
Seeds saved on inside rows (seeds ha^{-1})	Slight to medium	3,034.8
	Extreme	24,319.0
Excess seeds planted on outside rows (seeds ha^{-1})	Slight to medium	1,303.6
	Extreme	1,394.7
Cost saved on inside rows ($ ac^{-1})	Slight to medium	11.4
	Extreme	91.2
Loss on outside rows ($ ac^{-1})	Slight to medium	4.9
	Extreme	5.2
Total cost savings ($ ac^{-1})	Slight to medium	6.5
	Extreme	86.0

*Assumptions:
80,000 maize seeds/bag
US$300 per bag

Cost analysis further showed that for the fields examined with the characteristics described above, it will take a minimum of 5 years to pay back the investment when the planter covers 400 acres of slight to medium curve zones per year, while planting 30 acres per year of zones of extreme curves will recoup the investment in the same timeframe (Table 3). It should be noted that this study only considered the benefit of turn compensation on seed savings and did not include the advantages of savings gained from potential yield increase as a result of improved spacing across rows nor does it consider costs for spot treating weed infestations in a thin crop.

Table 3. Annual savings from turn compensation and number of years to pay back investment

Turn classification	Area covered (acre yr^{-1})	Cost savings ($ yr^{-1})	PP* (yr)
Slight to medium	200	3,206.54	10.0
	250	4,008.17	8.0
	300	4,809.81	6.7
	350	5,611.44	5.7
	400	6,413.08	5.0
Extreme	10	2,123.35	15.1
	20	4,246.69	7.5
	30	6,370.04	5.0
	40	8,493.39	3.8
	50	10,616.74	3.0

* Payback period (PP) assuming cost of turn compensation on a planter is $32,000.

Summary

The key practical advantage of using turn compensation on planters relies in the seed savings through reduction of overplanting and underplanting when navigating turns of various radii across the field.
In summary, turn compensation can provide the following advantage to growers:

- Consistent plant density. Turn compensation reduces plant spacing variability leading to consistent planting density across all rows. This technology ensures correct row-to-row population control whenever making turns, navigating waterways, terraces, and other field obstacles during planting.
- Maximize yield potential. Inconsistent seed placement across the rows can impact yield. Maintain consistent population is essential for uniform stands and a key to maximum yield potential.
- Financial benefits. Optimizing the use of agricultural input would reduce production costs and increase profit. The ability of turn compensation to minimize losses due to over- and under-planting can result in financial gains for growers.

This extension article presents the value proposition of what a turn compensation on planter can provide that can be used as decision tool to help growers evaluate this technology prior to purchase. For more information about commercially available turn compensation technology, visit the following websites:

https://www.agleader.com/planting/suredrive/

https://www.horsch.com/us/products/intelligence/curve-compensation

https://www.precisionplanting.com/products/planters/vset

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