Track and tyre width influences sprayer boom movement

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Track and tyre width influences sprayer boom movement

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Summary

The effect of wheel track width, 1.50m, 1.80m and 2.25 on sprayer boom movement was evaluated on a standard bumpy track and on a grass field. The sprayer used was a self propelled 33m working width machine with hydraulic adjustable track width. Sprayer boom movement was measured in the horizontal plane with a laser distance-measuring device and simultaneously in the vertical plane with an ultrasonic device. Difference in sprayer boom movement was expressed as minimum and maximum values for displacement and speed changes. The time during which the sprayer boom was within limits of ± 10 cm from initial boom height and ± 10% from average speed are presented. It is shown that increasing track width decreases the sprayer boom movement. On a grass field a wider tyre width decreases sprayer boom movement even further. The methodology used is presented as an initial approach for developing a classification system for boom stability of field crop sprayers.

Key words: sprayer boom movement, track width, bumpy track

Introduction

Legislation in the Netherlands is aimed at a reduction of plant protection products that contaminate soil, (surface) water and air; particularly the drift deposition, where spraying, contributes to the contamination of water surface. Therefore spray free and crop free buffer zones are introduced to minimise the risk (Water Pollution Act, Plant Protection Act). Field measurements of spray drift from boom sprayers operating over arable crops have shown that drift decreases with lower boom heights (Jong et al, 2000; Stallinga et al 2004). As the working width of the sprayers is increasing to more than 40m, it is questioned whether boom stability is still adequate to maintain boom heights at low settings. It is known that sprayer type - hitched, trailed or self-propelled, has an influence on boom movement. Demonstrations (Lebeau *et al*., 2001; Korver & Van Rhee, 1997) and tests have shown the effect of boom construction, suspension system, sprayer speed (Bondesson, 1987), tyre type, and inflation pressure (Langenakens et al., 1995) as well as the liquid level of the tank (Clijmans & Ramon, 1997). It is known that boom movements have an effect on spray deposition (Speelman & Jansen, 1974; Sinfort & Herbst, 1995; Jong *et al.,* 2000) and on spray drift (Zande, 2002). As sprayers are increasing in size and working width, more of them are self-propelled. Track width is increasing from the usual 1.50 m to 1.80 m, and crop establishment is adapted to spraying on wide tracks (e.g. 2.25m), where wheel passages are un-seeded. Contractors use sprayers in many different crops with varying row spacing and move from farm to farm with different standardised row width, e.g. potatoes on 0.75m or 0.90 m ridges. Accordingly, more self-propelled sprayers are equipped with adjustable track-width systems. No information is available on the effect of track width on the stability of the spray boom. Research results are presented on the influence of track widths of 1.50m, 1.80m, and 2.25m on sprayer boom movement, resulting from passes over a standardised bumpy track (ISO5008, 1979) and over grassland. Measurements are also presented for the effect of tyre width in combination with the widest track-width of 2.25 m. The measuring system, to quantify boom movement, consisted of an ultra-sonic sensor to measure boom tip height and a laser distance measuring device to monitor the horizontal position of the boom relative to a fixed point where the laser was positioned (Jong *et al*., 2000).

Materials and Methods

Sprayer boom movement

To quantify the boom height and position in the field during spraying, measurements were checked with a system (Fig. 1) consisting of a laser distance indicator and an ultrasonic sound height sensor (Jong *et al*., 2000). The ultrasonic sensor (AE, P42-A4N-2D-1C1-130) was connected to the end of the sprayer boom facing downward to the ground, and measured vertical position and movement. The data of the ultrasonic was directly sent (ADAM 4550) to the computer connected to the laser-measuring device. The position of the boom tip was measured with a laser distance-measuring device (Sick DME 200). From a fixed position the laser point was (manually) directed at a reflection shield mounted on the boom tip. Maximum measuring distance was 100m with an accuracy of 1mm. The system checked the distance and height of the boom tip in the field every 0.1 second intervals. Boom height and the distance measurements were synchronised, and together with the time, recorded online. From both the horizontal and vertical positions in time the horizontal and vertical speeds of the boom tip were derived as a difference between actual positions in time. Horizontal movement of the boom tip was derived from the difference between actual position and the position based on the average calculated speed at the same time.

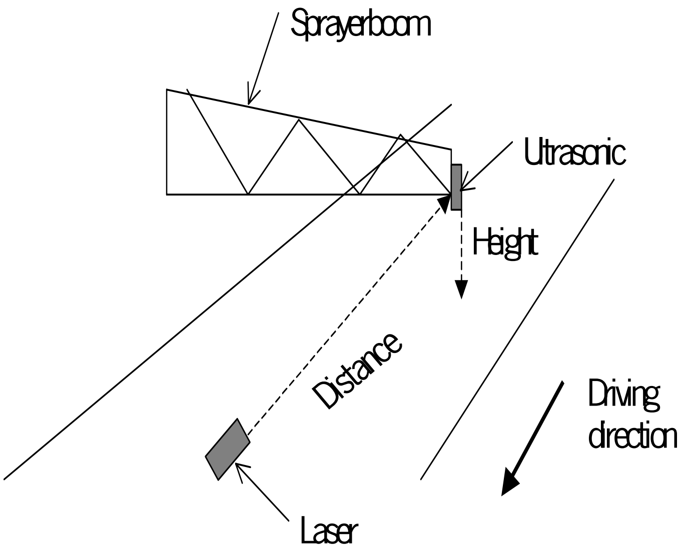


Fig. 1. Schematic view of the boom movement measuring system with the laser and ultrasonic sound system (after Jong et al., 2000).

Spray track

Sprayer boom movements were measured on two different track types, a standard or bumpy track, and on grassland. Track-widths of the sprayer were set at 1.50m, 1.80m and 2.25m. Before testing, the sprayer boom height was set to 1.20m above soil surface. All measurements were replicated ten times. Sprayer speed during measurements was 6.2 km/h.

The used bumpy track was identical to the one specified in ISO5008, the smooth part, and had a length of 50m. The track was placed on a concrete surface. The bumpy track was adapted to the sprayer track-width by adjusting the right hand side track. A minimum free driving distance of 30m was maintained, before entering the bumpy track, to minimise starting/accelerating effects on boom movement. Although the track was smoothed towards the start and end of the bumpy track to minimise ride on and ride off effects the measurements of the first and last 5m of the bumpy track were not included in the evaluation.

The boom movement experiments on grassland were performed by repeatedly moving over the same track on a grass field next to the bumpy tracks concrete path. After two initial passes over the track, spray runs were replicated ten times over the same track and boom movements were measured. Total length of the track was 150 m, of which the first 30 m was not in the boom movement measurement assessment. Boom movement was, as with the bumpy track, also evaluated over a length of 40 m.

Used spray techniques

Specifications of the self-propelled sprayer equipped with a hydraulic track width adjustment system used in the experiments are as summarised in Table 1.

Table 1. *Specifications of the field sprayer used for the boom movement measurements*

spray technique	Self propelled conventional field sprayer
machine	Delvano EURO-TRAC
working width	33m
nozzle spacing	0.50m
driving speed	6k/h
track width	variable between 1.50 -2.25m; hydraulically
suspension	all 4 wheels individually
tyres	narrow = 300/95 12.4 R 46; 2 bar
	wide = 460/85 18.4 R 38; 2 bar
wheel basis	3.30m
total length	9.00m
empty weight	8700kg
tank capacity	3100 l; including 250 l clean water tank, empty

Presentation of results

Results of boom movement measurements are presented as horizontal and vertical components separately. The vertical components consist of: the variation in height compared to initial set boom height, the standard deviation of measured boom height evaluated over 40 m every 0.1 sec and the time period the boom tip was within a range of heights of ± 0.1m of initial height over 40m length. The horizontal components were: the variation in distance compared to the calculated position based on the calculated average speed of the boom tip, the standard deviation of horizontal boom movement evaluated over 40m every 0.1 sec, the boom tip speed over a length of 40m per 0.1 sec, and the time the boom tip was within a range of speeds of ± 10% of average speed over 40m track length.

Differences were analysed with a standard statistical package (GENSTAT, analysis of variance; Payne et al., 1993) at a 95% confidence interval.

Results

When the sprayer passed over either the bumpy track or the grassland track, boom movements were measured. The movements were evaluated over a length of 40m. From vertical displacement data of ten measurements it was clear that the movements are reproducible and that they can be presented as an average movement with a deviation margin around it (Fig. 2). Average movements are presented therefore for the vertical and the horizontal movements of the sprayer boom tip as recorded on the bumpy track and on the grassland.

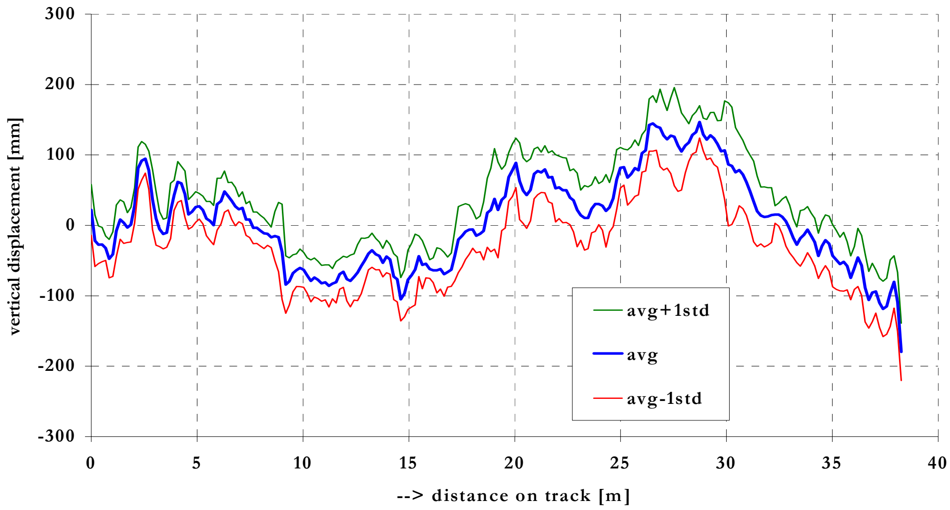


Fig. 2. Average boom movement in the vertical plane of 10 measurements and its standard deviation over 40m length of the bumpy track (track-width 2.25m, small tyre)

Boom movements in the vertical plane

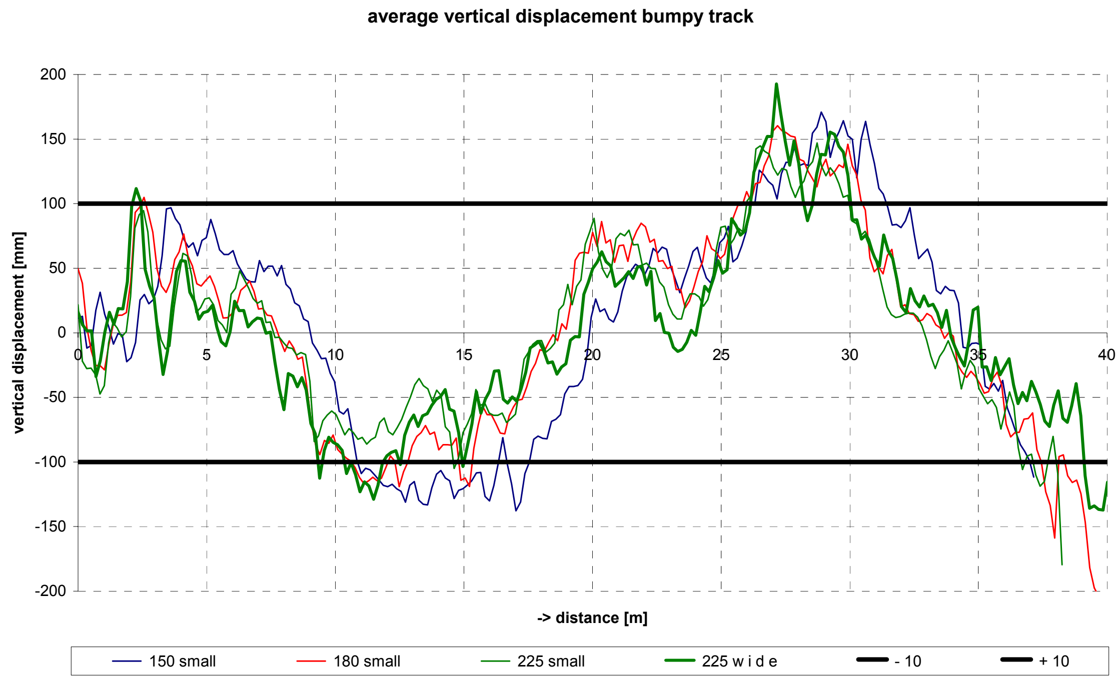
Results of the measured boom movements in the vertical plane are presented in Fig. 3 for the bumpy track and the grassland. To quantify the data the average standard deviation of boom heights and the percentage of time the boom tip was within a 10cm band width of the initial height is presented for the two surfaces, tyre widths and track widths in Table 2.

Table 2. *Vertical boom movements characterised as standard deviation of the average boom height and as % of time in the height class < 10cm height difference for different surfaces, track-width of the sprayer and tyre*

surface	tyre	track width [cm]	speed mm/s	speed km/h	n	avg. st dev height [cm]			% time height difference <10cm		
bumpy track	small	150	1722	6.2	7	10	a		64	a	
bumpy track	small	180	1704	6.1	9	9	b		72	b	
bumpy track	small	225	1723	6.2	10	8	c	x	80	c	x
bumpy track	wide	225	1738	6.3	10	9		x	76		x
grass	small	150	1711	6.2	9	8	a		78	a	
grass	small	180	1798	6.5	10	5	b		94	b	
grass	small	225	1791	6.4	10	8	a	x	76	a	x
grass	wide	225	1741	6.3	10	6		y	93		y

n = number measurements
a = same letter means no difference ($\alpha = 0{,}05$) between track-width
x = same letter means no difference ($\alpha = 0{,}05$) between tyre width

The average standard deviation of the height measurements is a parameter to quantify the stability of the boom in the vertical plane. The lower the value the less movement of the boom occurred during the pass over the tracks. Movements are small, only 5-10cm measured over a track length of 40m with a sprayer having a boom width of 33m. On the bumpy track the



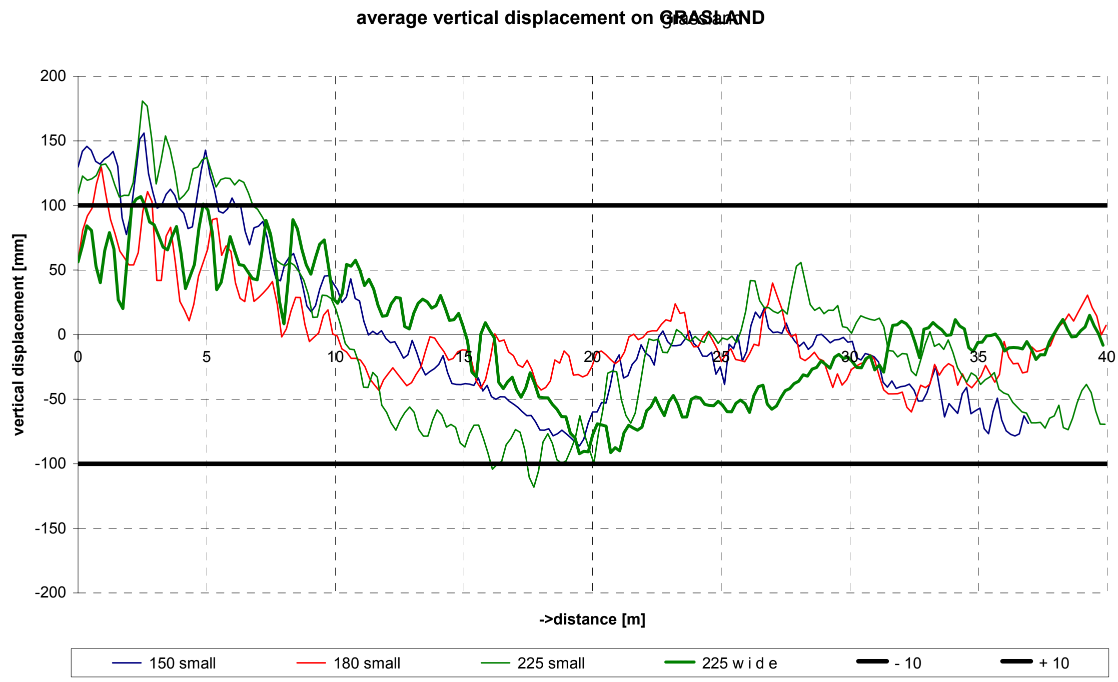


Fig. 3. Average vertical displacement (mm) of the spray boom tip when moving over a 40m bumpy track (top) and over grassland (bottom) with track-widths of 1.50m, 1.80m and 2.25m with small or wide tyres

vertical movement decreases with increasing track-width, with no effect of tyre width for the 2.25m track-width. On the grass surface the 1.80m track-width resulted in the smallest vertical movement.

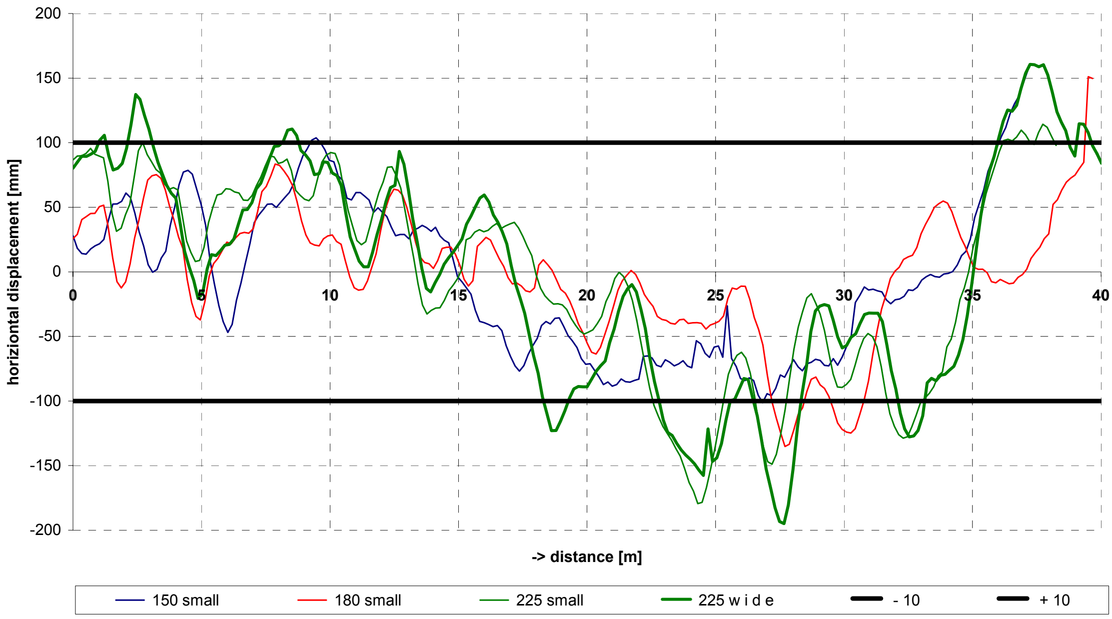
When using wider tyres at a track-width of 2.25m vertical movements could be lower than for small tyres. The time during which the boom tip was within a 10cm limit from initial set boom height is, when passing over the bumpy track, highest for the widest track-width (2.25m) 80%.

No difference occurs between tyre widths. On the grass surface this time fraction was 94% for the 1.80m track-width and 93% for the 2.25m track-width with wide tyres. The wide tyres increased this time fraction from 76% for the small tyres.

Boom movements in the horizontal plane

Results of the measured boom movements in the horizontal plane are presented in Fig. 4 for both the bumpy track and the grassland. To quantify the data the average standard deviation of horizontal boom movement, the average deviation in boom speed, and the percentage of time for which the speed was less than 10% different from the average speed is presented for the two surfaces, tyre widths and track widths in Table 3.

average horizontal displacement bumpy track



average horizontal displacement on GRASSLAND

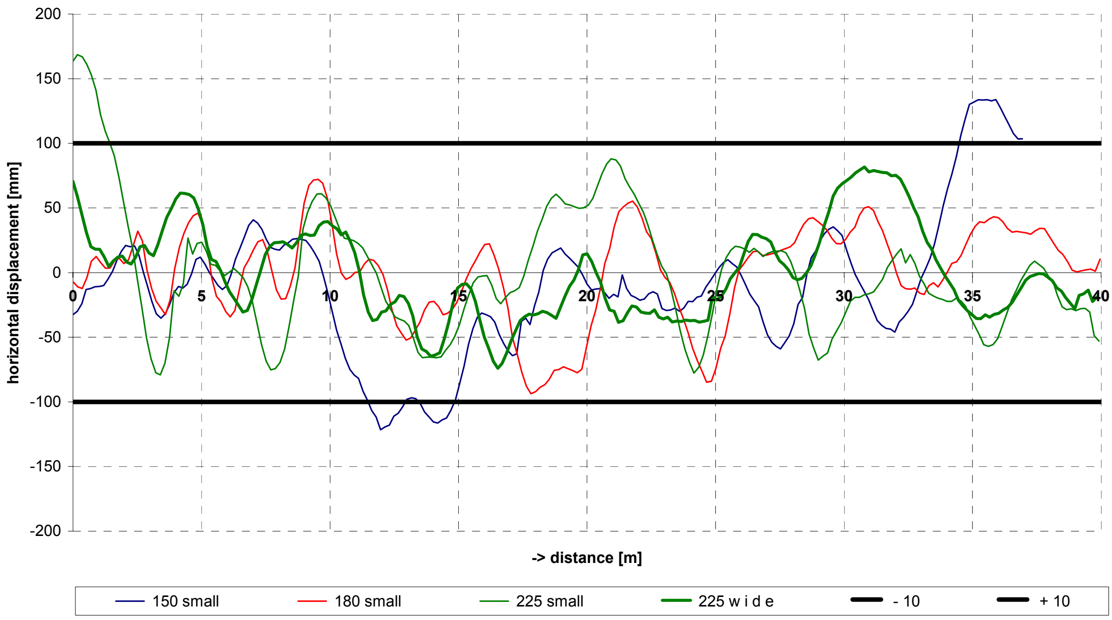


Fig. 4. Average horizontal displacement (mm) of the spray boom tip when moving over a 40m bumpy track (top) and over grassland (bottom) with track-widths of 1.50m, 1.80m and 2.25m with small or wide tyres

Table 3: *Horizontal boom movements characterised as standard deviation of the average horizontal boom movement, average deviation in boom speed and as % of time in the speed class < 10% speed difference of the boom tip for different surfaces, track-width of the sprayer and tyre width*

surface	tyre	track width [cm]	speed mm/s	speed km/h	n	avg. deviation on average horizontal movement [cm]			avg. speed deviation [cm/s]			% time speed deviation from avg. speed < 10%		
bumpy track	small	150	1722	6.2	7	15	a		14	a		67	a	
	small	180	1704	6.1	9	11	b		15	a		66	a	
	small	225	1723	6.2	10	12	b	x	14	a	x	68	a	x
	wide	225	1738	6.3	10	13		x	16		y	64		y
grass	small	150	1711	6.2	9	8	a		10	a		85	a	
	small	180	1798	6.5	10	6	b		10	a		85	a	
	small	225	1791	6.4	10	8	a	x	11	a	x	81	a	x
	wide	225	1741	6.3	10	7		x	9		y	90		y

n = number measurements
a = same letter means no difference ($\alpha = 0,05$) between track-width
x = same letter means no difference ($\alpha = 0,05$) between tyre width

Particularly relevant for spray deposition is the variation in boom speed. On the bumpy track little difference is found in variation of the horizontal speed of the boom tip for the different track-widths. The deviation of the horizontal movement is however highest for the small track width (1.50m). On the grass surface horizontal movements of the boom tip are smaller than on the bumpy track, being lowest for the 1.80m track-width. No difference was found in average speed deviation of the boom tip or the time where the deviation of the tip speed was less than 10% for the track-widths in combination with the small tyre width. At 2.25m track-width the wide tyre performance was clearly better than the small tyre width, 90 % of the time giving a boom tip speed within a 10% deviation of average travelling speed.

Discussion

Although differences between track-widths on the boom movements are small they can be measured in such a way that significant differences can be presented. The time period that the boom tip is within a height band from the initial height setting is a clear and easy to understand parameter that can be used to categorise and classify sprayer boom movements. The same applies if the time period the boom tip speed deviates not more than, for example, 10% from average travelling speed. The differences between measurements show that, when in good condition, a standard bumpy track, as well as a prepared track on a grass surface, can give repeatable results in sprayer boom movement. Effects of sprayer setting can then be evaluated, if enough passes are replicated over sufficient track length.

On the bumpy track, best results for boom stability were achieved with the wide track of 2.25m. On a grass surface the most stable situation was the 2.25m track-width and wide tyre combination. For this combination the time period in which the speed deviation from average travelling speed was less than 10% was on the bumpy track 64%, and on the grass surface 90%. The time period the boom height was within a 10cm bandwidth of initial set boom height was on the bumpy track 76%, and on the grass surface 93%.

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