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Development of sensor system for detection of choking of the boot of maize planter

Rajat Ghorke and Babban Yadav

Abstract
An embedded system for detecting choking of boot of a maize planter has been developed (in laboratory). This system comprised a direct incidence infrared sensor for detection of choking of the boot of a maize planter with maize seeds and an Arduino uno board for receiving the input signals from the sensors. Based on these input signals and with the help of proper code, the Arduino UNO provided output signals (both visual and audible). Direct incidence IR sensor was installed to the fabricated cone shaped G.I. pipe which was then attached in between the boot and seed tube of the maize planter. At different seed rate (18,22,25,29 kg/ha) and at different metering plate RPM (6,14,22,30) an average time delay (Time between actual choking started and choking detected by sensor) in the detection of choking was varied from 3300 – 9500 MS.

Keywords: choking detection, direct incidence IR sensor, embedded system

Introduction
Sowing is one of the important operations for raising crops in which proper placement of seed in the soil for optimum growth is very much desired (Gursoy, 2014) [1]. Sowing is done by using seed drill/planter driven by tractor, power tiller, animal. Mechanization level of India is 40% and with increase in mechanization level in India and non-availability of animate power, tractor drawn planter is gaining popularity for sowing different crops. Therefore, having a clue about their performance is much desired and attempts are required to increase the quality of sowing and the mechanization level in sowing. The tractor drawn planter is usually attached to the three-point linkage system of the tractor, which is located behind the tractor. During operation, the metering of seeds is done by metering mechanism of the seed planter and metering mechanism takes the drive from the ground wheel. Performance of a planter depends on whether seeds are dropped into the furrow or not. As the performance of the planter and its components is entirely invisible to the operator, no clues about sowing quality during field operation are available (Xia *et al*., 2010) [2].

When the planter is pulled by a tractor, seeds are dropped into the furrows and those furrows are immediately closed by furrow closer, the tractor operator does not able to see whether seeds are dropped from the seed tube into the furrows or not because during operation of planter choking of seed delivery tube due to sticking of damp soil and accumulation of agriculture residues inside the boot resulting in accumulation of seeds in the delivery tube. (Kumar and Raheman, 2018) [3]. Farmers uses transparent seed tubes in a planter/drill to detect a chocking at boot of the planter, they detect a chocking by walking behind the planter by observing the seed tubes. If they observe accumulation of seeds in a transparent seed delivery tube it means chocking has started some time before. In short farmers are not able to detect chocking early. Hence, to increase the quality of sowing, these problems are required to be overcome. While operating a seed planter, missing of seeds in the furrow occurs mainly due to the boot of seed planter is choked (Cuhac *et al*.) Despite all these problems, the desired population of seeds for getting more yield by farmer is possible, if operator gets information on whether seeds are dropped into the furrow or not. With the increasing use of sensor systems in agriculture, attempts are required to sense choking of boot of seed planter. Only sensing of choking and may not help the operator, there should be some system to indicate or alert the operator regarding choking of boot of planter for successful sowing of seeds and timeliness operation.

Many a researcher have tried to detect seed/seedling passage by using IR sensor and hall sensor (Deividson L. *et al*, 2014, A. Bangura *et al*, 2018) [4, 5].

Many researchers have tried to detect seed flow of seed delivery tube by using capacitance sensor, fiber sensor, IR sensor (Yujing Sun *et al*, 2013, Hadi Karimi *et al*, 2017, A. Bangura *et al*, 2018, Besharatia *et al*, 2019) [6, 7, 5, 8]. Among these, IR sensor was found better because of high sensing efficiency, smaller size and low cost. Researcher also tried to detect the choking of boot and detection of seed flow by using the direct incidence and indirect incidence IR sensor (Rajeev Kumar *et al*,2018) [3]. researcher used indirect incidence IR sensor for sensing flow of seeds of the seed delivery tube and researcher also used direct incidence IR sensor for sensing choking of the boot of the seed drill.

Therefore, by keeping the above points in view the present study was undertaken to design and develop an embedded system for detection of choking which gives both visual and audible output in case of choking detection

Materials and Method

Concept of the developed system

An embedded system was developed for detection of choking of the boot with a single row inclined plate maize planter in a laboratory. (Figure1 shows concept behind the developed system.) In this embedded system direct incidence IR sensor was used for detection of chocking, and the sensor detected a choking in the boot when the receiver didn't receive rays emitted by the emitter due to accumulation of seeds in the boot. The microcontroller Arduino UNO gave power to a sensor and output of a sensor was fed to an Arduino UNO microcontroller board. Based on this output signal of sensor and programming code, the Arduino UNO microcontroller board provided the output signal which result in activating both visual (LED RED) and audible (buzzers) alerts simultaneously in case of choking detection.

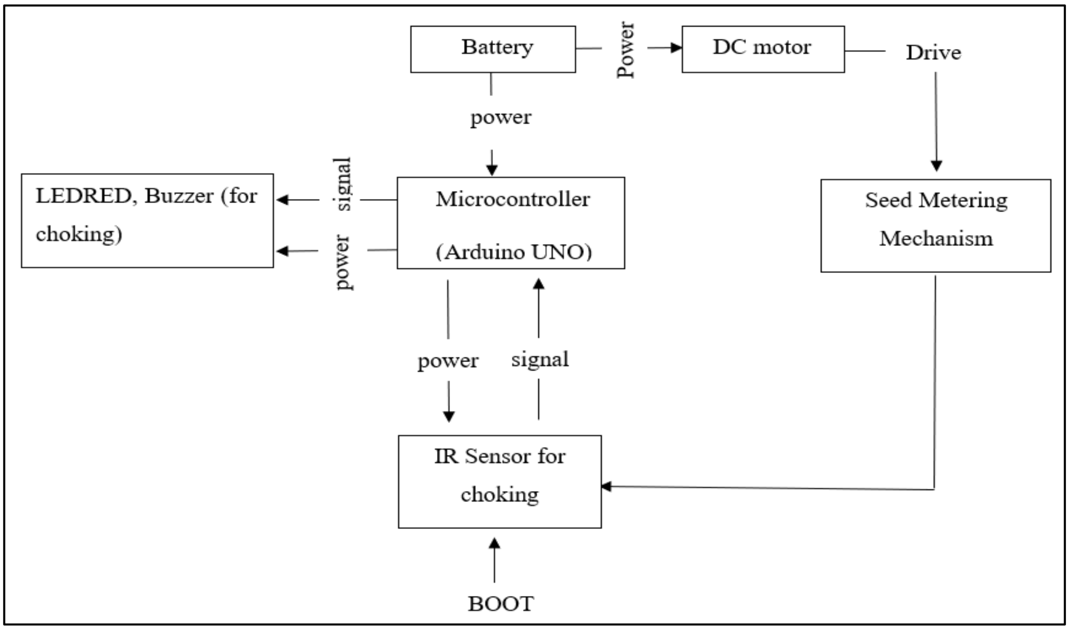

Fig 1: Block diagram of concept of developed system

Material used

Fabricated Cone shaped G.I. pipe for installing direct incidence IR sensor

The cone-shaped metal pipe was fabricated to fix a direct incidence IR sensor which has a top diameter of 3 inches and a bottom diameter of 1 inch. The direct incidence IR sensor consist 1 IR LED and 1 IR receiver. Both were fixed opposite to each other or 180 degrees apart at the bottom end of the cone-shaped pipe (Figure 2) top view of the fixed IR sensor at the bottom end of G.I. pipe is shown in figure 3. and the seed delivery tube of recommended dia. 1 inch (IS 6813, 2000) was inserted on the top of the cone shaped G.I. pipe through a hole provided on cover in such a way that the seeds were drop in front of the IR LED and IR receiver.

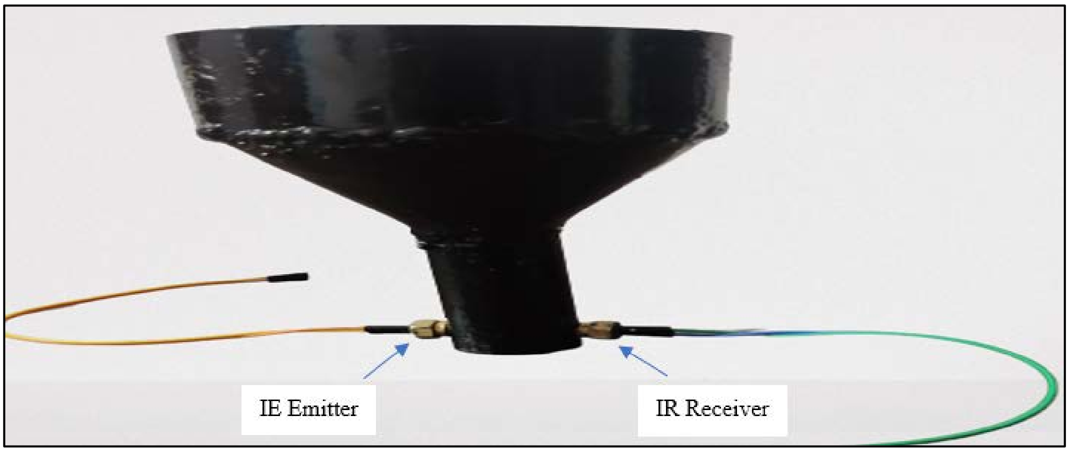

Fig 2: Cone shaped G.I. pipe used to fix direct incidence IR sensor

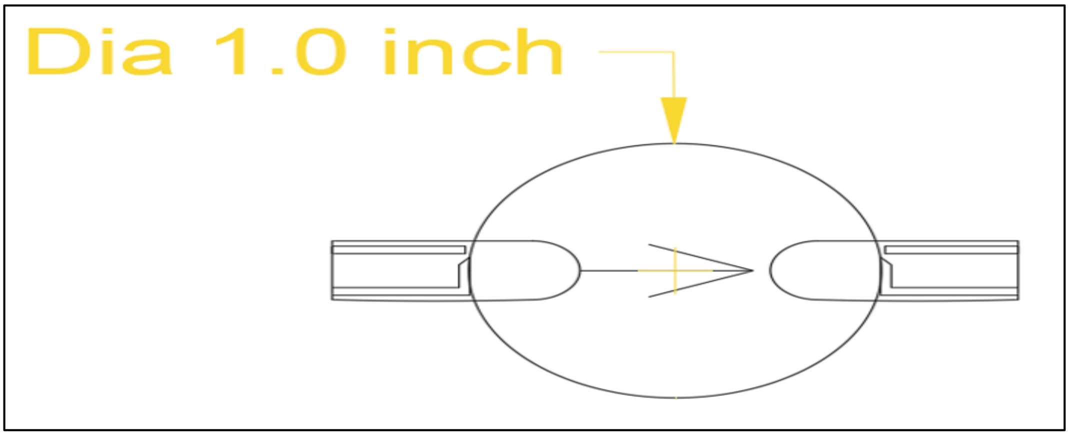

Fig 3: Top view of the bottom portion of the G.I. pipe

Direct incidence IR sensor was powered by 5Volt DC taken from the Arduino UNO board and Arduino UNO was powered by the battery. Circuit diagram of the developed embedded system for choking detection is shown in figure4. In circuit diagram IR LED was the source of IR rays, when choking was done accumulation of seeds inside the G.I. pipe was started and the rays emitted by the IR LED was absorbed or reflected back by the seeds and receiver did not able to get the emitted rays or the path of the IR rays was interrupted by the seeds and this interrupted signal input was fed to the Arduino UNO board and the Arduino UNO board gave the output in a visual/audible form (LED red/BUZZER) with the help of proper embedded code.

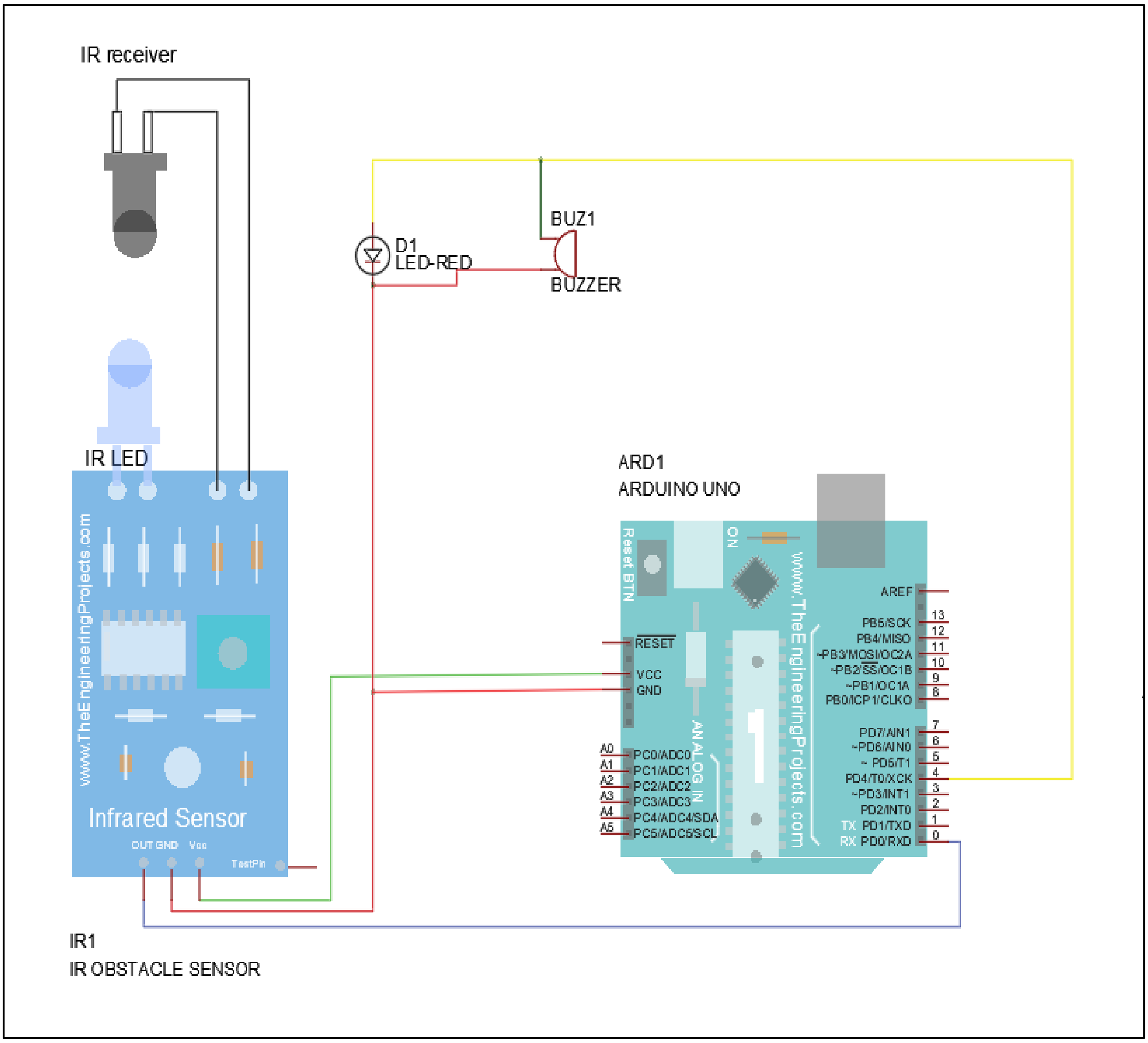

Fig 4: Circuit diagram of the embedded system for choking detection

Developed experimental setup

A laboratory setup was fabricated to test the developed embedded system for sensing choking of boot It comprised a hopper to store seeds, a commercially available seed metering plate, chain-sprocket type power transmission system was used which transmits power from ground wheel to the top shaft and the bevel gear was used to transmit power from top shaft to the inclined plate shaft, a DC motor (car's viper motor) powered by 12 V DC battery to rotate the power transmission system by coupling it to the shaft of ground wheel with the help of small size chain sprocket(timing chain of IC engine) as shown in figure8. Developed sensor system was fixed to the lower end of seed tube (Figure5) in such a way that the IR LEDS and IR receiver of the sensor were in the line of seed delivery tube and connected to the developed embedded system for sensing choking of boot. All the above components were fixed to a frame (50×50×75) made up of angle iron rods as shown in Figure 5.

Fig 5: Developed experimental setup

Working of developed embedded system in the experimental setup

In the developed experimental setup Choking of the boot was done by covering the bottom portion of the G.I. pipe by hand which result in accumulation of seeds inside the G.I. pipe thereby causing obstruction of IR light between IR LED and receiver. Input signal given by the sensor fed to the Arduino UNO board based on these input signal and the embedded programming code the microcontroller (Arduino UNO Board) provided output signal in both visual and audible form (red LED, BUZZER) in case of choking detection. The flow chart of the program of developed embedded system for controlling input/output signals is shown in Figure6. Decision box (diamond shape) in the program flow chart is used for choking of boot of maize planter based on input signal of direct incidence IR sensor.

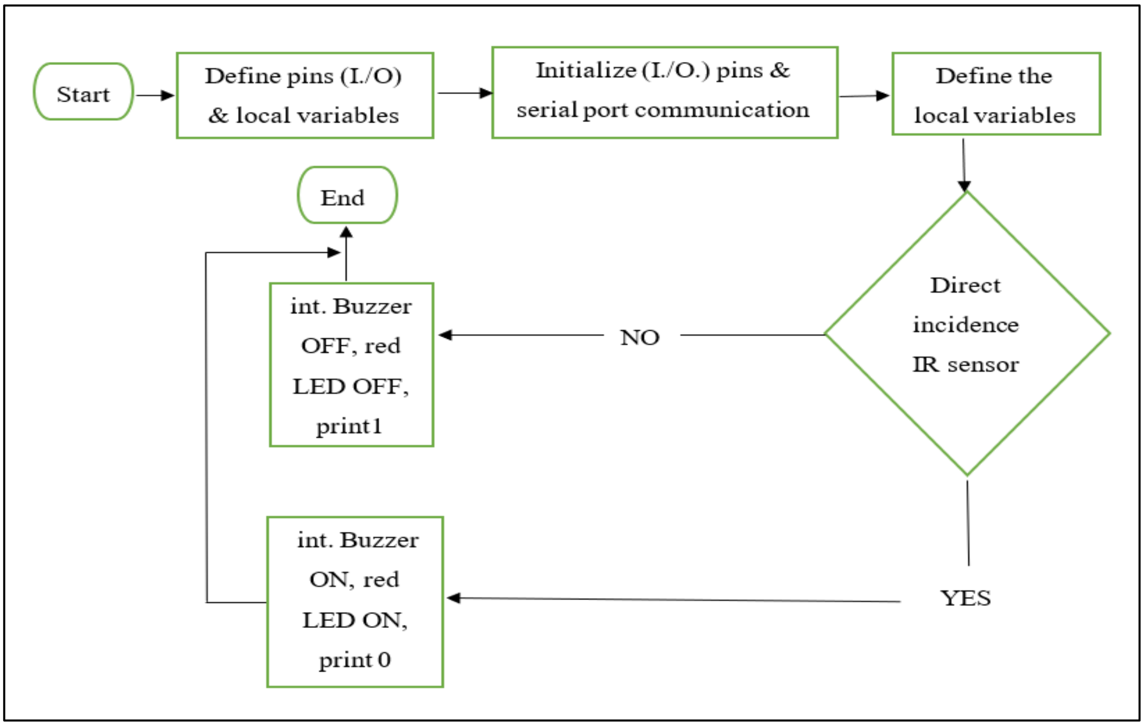

Fig 6: Program flow chart for developed embedded system

Data collection of the developed embedded system

In laboratory collection of data of the choking detection for developed embedded system with maize seeds was done and data of choking was taken separately at different seed rates (18, 22, 25, 29 kg/ha) and at different metering plate RPM (6, 14, 22, 30). Seed rate per unit time was varied by changing the ground wheel RPM which indirectly changes the RPM of metering plate. Assuming the row spacing 65cm, area covered by one furrow opener was calculated and seed rate (g/min) was obtained. Different seed rates of 18, 22, 25, 29 was obtained at the ground wheel RPM 10, 20, 30, 40 as shown in table 2. (Assuming the recommended row spacing 65cm.)

$$\text{Seed Rate } \left(\frac{\text{Kg}}{\text{ha}}\right) = \frac{\text{kg seeds dropped by planter per rev.}}{\text{C}\times\text{RS}\times\text{n (ha)}} \times 10000$$

C=circumference of ground wheel (2Πr, m.)
RS= recommended row spacing of maize(m.)
n= no. of revolutions of ground wheel

In the developed laboratory setup seeds were made to drop continuously from seed hopper to the collection tray at different metering plate RPM and at different seed rates. For different metering plate RPM and seed rates, data (Time delay in detection of choking) of choking was taken by using stopwatch. When the sensor detected choking of boot of maize planter, digital Read of program gave a binary output '0' (Low voltage, buzzer ON, red LED ON, Figure 6) and when the sensor did not detect choking of boot of planter, digital Read of program gave a binary output '1' (high voltage, buzzer OFF, red LED OFF, Figure6). Display unit of choking detection is shown in figure 7.

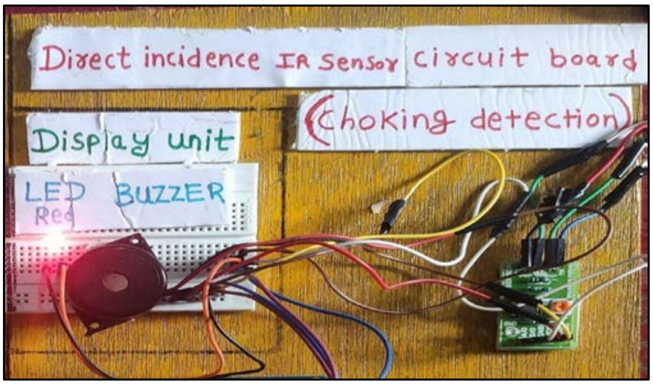

Fig 7: Display unit for choking detection

Results and Discussion

To determine physical properties of maize seed (dimensions) vernier caliper was used. Physical properties of maize seeds used is shown in Table1. Seeds were made to drop from inclined seed hopper to the seed container at different seed metering plate RPM and seed rates and data of time delay in sensing of choking by direct incidence IR sensor was obtained by recording the time between the actual choking started (By covering the bottom portion of the GI pipe) and choking detected by the sensor. Data collected of choking is shown in Table 2 and from this collected data, it can be seen that at higher seed rate (29 kg/ha) and at higher metering plate RPM (30), detection of choking by the sensor was faster (delay time in sensing reduced) as compared to lesser seed rate (18 kg/ha) and lesser metering plate RPM (6). From the data collected of choking, it can be seen that at higher seed rate (29 kg/ha) and at higher metering plate RPM (30), detection of choking by the sensor was faster (delay time in sensing reduced) as compared to lesser seed rate (18 kg/ha) and lesser metering plate RPM (6). From these experimental observations, it was concluded that sensing of choking with the developed embedded system was possible at an average time delay varying from 3300 to 9500 MS and it was dependent on seed rate and RPM of seed metering plate.

Table 1: Physical properties of maize seeds

S.I.no.	Seed properties	Value
1	Bulk Density(kg/m3)	1864.96
2	Length(mm)	12
3	Width(mm)	11
4	Thickness(mm)	4
5	Geometric diameter (mm)	
	Sample 1	8
	Sample2	6.4
	Sample3	5.5

Table 2: Time taken for detection of choking by direct incidence IR sensor at different ground wheel rpm and seed rate

Metering plate	Seed rate	Time delay in sensing, ms				
RPM	4^1(kg/ha)	T1	T2	T3	Average	SD
30	29	4000	3000	3000	3300	538.9
22 __	25	3000	4000	4500	3800	764.8
14	22	7000	6000	5000	6000	578.7
6	18	9000	10000	9500	9500	158.1

(T1, T2, T3 = no. of tests at same ground wheel RPM and sed rate, SD = standard deviation).

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