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Sensor for seedling spacing and flow measurement in vegetable transplanter

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ABSTRACT : An opto-electric sensor was developed for measuring seedling spacing and seedling flow through seedling delivery tube. It was evaluated both in soil bin and field conditions. Seedling spacing was determined from signals obtained by sensor in soil bin and field conditions by data acquisition system and oscilloscope, respectively. At 45 cm seedling spacing, variation in seedling spacing measured manually and by sensor at 0.6 to 2.2 km/h speeds for tomato, brinjal and chilli in soil bin were analyzed for all type of seedlings used and for entire range of speed varied from 1 to 2.16 cm and 0.99 to 1.62 cm for tomato, 0.06 to 0.92 cm and 1.08 to 2.2 cm for brinjal, 0.98 to 1.89 cm and 0.45to 1.32 cm for chilli, respectively where as in field conditions it varied from 1 to 2.16 cm and 0.99 to 1.62 cm for tomato, 0.06 to 0.92 cm and 1.08 to 2.2 cm for brinjal, 0.98 to 1.89 cm and 0.45 to1.32 cm for chilli, respectively.

KEY WORDS : Optoelectric sensor, Seedling spacing, Seedling flow, Vegetable transplanter

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After raising good quality seedlings, transplanting them in the field with uniform spacing is one of the stages in the production of many vegetable crops (Singh, 2008). It is carried out by vegetable transplanters using various type of metering mechanisms (Shaw, 1997). Uniform spacing between plants provides enough space for the plant to grow and develop and reduce the nutrient uptake competition between plant and weeds by depressing the weed growth (Heege, 1993). Hence, evaluation of metering mechanism is, therefore, essential as it is required for maintaining the recommended plant spacing and population. The conventional method for seedling spacing measurement in the field is manual and is a very tedious process. Most of the studies on seed spacing evaluation were made either with a sticky belt test stand or an optoelectronic sensor (Raheman and Singh 2003; Panning *et al.*, 2000; Kocher *et al.*, 1998) high-speed camera system used of wheat and soybean seeds (Karayel *et al.*, 2006). From all the tests he found that the high-speed camera system did not miss any seed but costlier attempt for paper pot seedling spacing detection. Hence, opto-electric sensor was developed for proper detection of seedling flow. In automatic vegetable transplanters, the seedlings are fed to the metering mechanism and transplanted in the field without human intervention. It is very difficult for the tractor operator to see the workability of the metering unit while working in the field. Therefore, an attempt was made to develop a sensor which could show the flow of seedlings.

METHODOLOGY

Development of light sensor and working principle:

The developed sensor comprised a power supply unit, transformer, rectifier diodes, regulator IC, capacitors, light source, optical sensor, comparator and LED. Detailed drawing with component designation is shown in Fig. A. Two options both 12 V battery and 220 V AC supply were kept to supply the power to the opto-electric sensor circuit so that in the laboratory it could be operated by 220 V AC supply. Working principle of a sensor is based on light. When the power was supplied to the circuit the transformer circuit could step-down the 220 V to 12 V AC supply. The rectifier circuit consisting of diodes was used for converting the AC supply to 12 V DC supply. One connection of 12 V DC was then sent to the regulator IC which reduced the 12 volt DC to 5V DC and sent to the light source. Another connection for supplying 12 V was given to the comparator from where the connection was made with light sensor. After comparator the output was measured through (J3) and the LED was placed in the circuit. When the power was supplied through either 12 V battery or 220 V AC supply, the light source emitted the light which was sensed by the optical light sensor. When the pot seedling in seedling delivery tube obstructed the light path, fluctuation of voltage occurred which were recorded by DAS over time

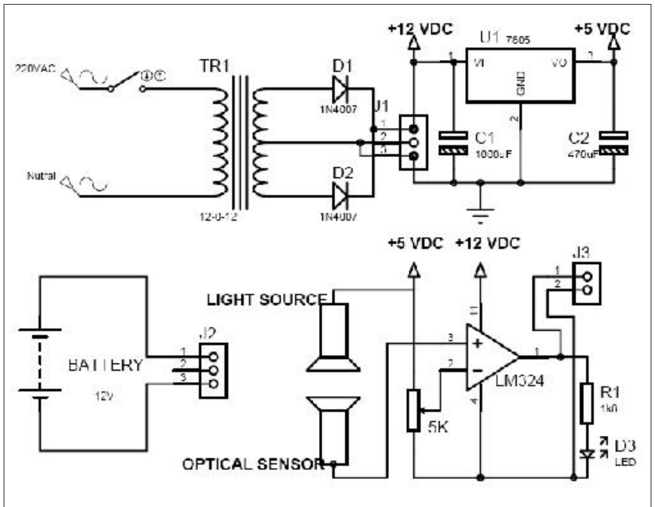

Fig. A : Curcuit digram of the developed sensor

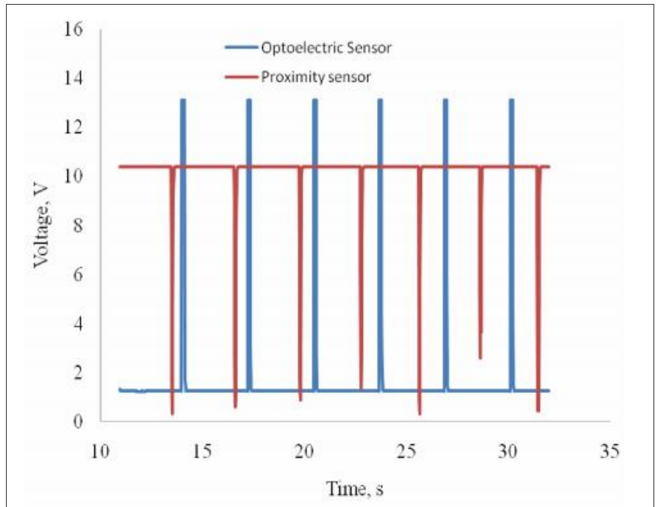

Fig. B : Sample output signals in DAS

(Fig. B). LED gets blinked every time when there was an obstruction on the light path. The plot of time verses voltage was used to measure the seedling spacing.

Evaluation of the developed seedling sensor in soil bin:

The developed experimental set-up (Fig. C) consisted of an indoor soil bin 15 m × 1.8 m × 0.6 m, a soil processing trolley (1), an implement trolley (2), metering mechanism setup (3), Electric motor (4), seedlings delivery tube (5), laptop (6), DAS (7), DC speed controller (8), a control panel for linear speed transmission system (9), proximity sensor (10) and an opto-electric sensor with both AC and DC power supply options (11).An opto-electric sensor was inserted in the wall of the seedling delivery tube of the developed metering mechanism setup for sensing the seedling flow and measurement of seedling spacing. The metering unit comprised metering wheel where the seedlings were kept and a slotted plate was placed at the bottom of the metering wheel to release the seedling pots which was then moving through a delivery tube to the ground. The metering unit was powered with 2.23 kW electric motor using a combination of gear and chain drive transmission. Rotary speed of metering unit was controlled by a DC speed controller. Forward speed of the setup was measured by proximity switch attached to the setup. The calibration of DC speed controller was carried out to synchronize the speed of metering with linear speed for obtaining plant spacings of 45 cm.

Test procedure:

Soil bin condition:

Pot seedlings of tomato, brinjal and chilli were used for evaluation of the developed setup. The heights for different

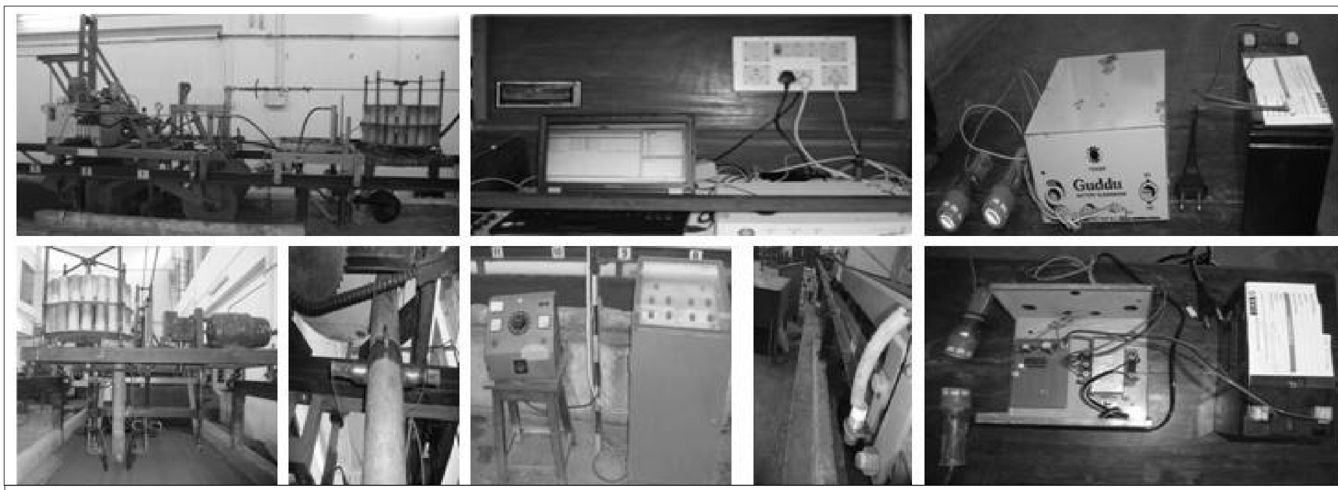

Fig. C : Soil bin setup for evaluating developed sensor

seedlings were in the range of 12±2 cm for tomato and 9±2 cm for both brinjal and chilli. Cylindrical shaped pots were used with diameter, height and maximum diagonal length of pot as 50±1 mm, 40±1 mm, 64±1 mm, respectively.

Forward movement of the whole metering setup was possible with a 7.46 kW electric motor coupled to a gear box having provision to change the forward speed from 0.6, 0.9, 1.2 and 2.2 km/h using gear shifting lever. A proximity switch was used to measure the actual forward speed of operation. The simulated field conditions were maintained in the soil bin for testing of the developed sensor. Cone index of about 225±25 kPa and a bulk density of 1.2±05 kg/m^3 and moisture content of 9.5±1 per cent (db) were maintained in the depth range of 0-80 mm of soil bed for each test. Cup type metering mechanism developed at Agricultural and Food Engineering Department, IIT Kharagpur was used for evaluation of the developed sensor. The seedlings were kept in the conical cups and rotary motion to the metering unit was given through DC speed controlled motor. Rotary speed of the metering unit was decided by inter plant spacing in the row. Plant spacings 45 cm were used for evaluation. Initially, all the electric connections were checked for proper working of the whole metering unit setup and opto-electric sensor circuit. 220 V AC supply was given to power the developed circuit. Data acquisition system and motor both were started at same time and data on plant spacing and actual speed of operation of the setup in terms of voltage were recorded. Data for four rotational speeds corresponding to four forward speeds (0.6, 0.8, 1.2 and 2.2 km/h) were collected for tomato brinjal and chilli plants. Sensor outputs were recorded in DAS and then were analyzed for finding the seedling spacing. The time intervals measured between the seedling falls, and front and back seedling drop location detected events were used to determine the seed spacing in the soil bin. The seedling spacing was calculated by using following formula :

$$\textbf{Seedling spacing (cm)} = \frac{(A-B)}{C-D} \times (E-F)$$

where,

(A-B) = Distance between front voltage peak (A) and back voltage peak (B) of the proximity sensor (cm)

(C-D) = Difference in time corresponding to front voltage peak (D) and back voltage peak (C) of the of proximity sensor (s)

(E-F) = Difference in time between front voltage peak (E) and back voltage peak (F) of the of optical sensor (s)

Field condition:

The sensor was fixed on the wall of the delivery tube of the metering mechanism. The oscilloscope was fixed on a frame near the footrest of the tractor operator (Fig. D). Power was supplied to the assembly by 12 V DC batteries. Digital oscilloscope (Make:Tectronix, Model TDS2002, 60MHz, 1GS/s) was used to store the seedling flow data and show the flow of seedlings through seedling delivery tube. The metering mechanism of the vegetable transplanter was filled with paper pot seedlings (40 seedlings) then vegetable transplanter was lowered to the ground. The speed of rotation of the metering unit was synchronized with forward speed of tractor by fixing gear ratio based on the plant spacing.. The tests were carried out for a range of speeds from 0.6 to 2.2 km/h. Data were collected in the field condition on seedling spacing and number of fall of seedlings both manually as well as by the sensor.

1. Oscilloscope 3. Optoelectric sensor 4. Optical sensor box

Fig. D : Field testing using developed sensor

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been summarized under following heads:

Evaluation in soil bin:

The tabulated values are the mean values for each speed and seedling type (Fig. 1). Data presented show the difference in the spacing detected by sensor and manually measured values. Seedling spacing measured manually and by sensor for all type of seedlings used for the entire range of speed varied from 45.54-46.16 cm and 45.19-45.62 cm for tomato, 45.19-45.62 cm and 45.02-45.50 cm for brinjal, 45.40-45.85 cm and 45.19-45.62 cm for chilli, respectively at the seedling spacing setting of 45 cm. The spacing variation was found to be within ±2 cm from the desired spacing.

Evaluation in field :

Variations among actual and sensor spacing in field condition for 45 cm is shown in Table 1. The data on seedling spacing were collected and analyzed and it shows that seedling spacing measured manually and by sensor for all type of seedlings used for the entire range of speeds.

It varied from 1-2.16 cm and 0.99-1.62 cm for tomato,

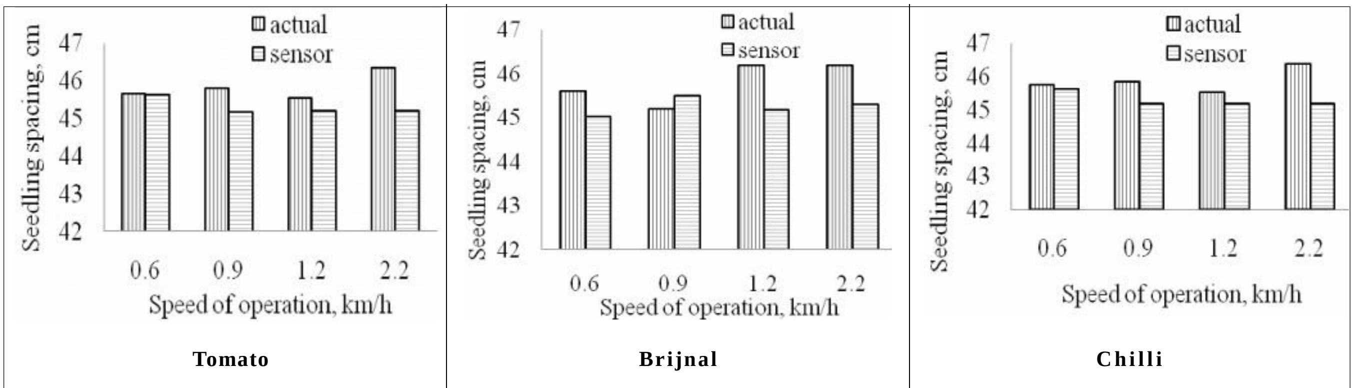

Fig. 1 : Comparison seedling spacing obtained manually and by the sensor

Table 1 : Variations among actual and sensor spacing in field condition for 45 cm

Speed, km/h	Tomato		Brinjal		Chilli	
	Manual	Sensor	Manual	Sensor	Manual	Sensor
0.6	0.65	1.62	0.06	1.02	0.98	0.45
0.9	0.81	0.18	0.21	1.50	1.85	1.18
1.2	1.20	0.99	0.19	1.08	1.54	1.19
2.2	2.16	0.99	0.92	1.22	1.80	1.32

0.06-0.92 cm and 1.08-2.2 cm for brinjal, 0.98-1.89 cm and 0.45-1.32 cm for chilli, respectively at the seedling spacing setting of 45 cm. The variation in spacing was found ±2.5 cm from the desired spacing and were well within the acceptable range of plant spacing.

Conclusion:

Developed sensor facilitated the seedling spacing measurement and flow through seedling delivery tube without missing a single seedling. It also showed the workability of the metering mechanism in terms of flow of seedling on the display of the oscilloscope. The stored data in the data card of the oscilloscope was used to determine the plant spacing in the field.

The variation in actual seedling spacing measured manually and by sensor was found to be varied within 2 per cent and it is well within acceptable limit of the seedling spacing. The developed sensor can be used on the automatic vegetable transplanter to determine the inter row seedling spacing and flow.

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■ REFERENCES

Heege, H.J. (1993). Seeding methods performance for cereals, rape, and beans. *Trans. ASAE,* **36** (3): 653–661.

Karayel, D., Wiesehoff, M., Ozmerzi, A., and Muller, J. (2006). Laboratory measurement of seed drill seed spacing and velocity of fall of seeds using high-speed camera system. *Computers & Electronic. Agric.*, **50**(2): 89-96

Kocher, M.F., Lan, Y., Chen, C. and Smith, J.A. (1998). Opto-electronic sensor system for rapid evaluation of planter seed spacing uniformity. *Trans. ASAE*, **41**(1) : 237-245.

Panning, J.W., Kocher, M.F., Smith, J.A. and Kachman, S.D. (2000). Laboratory and field testing of seed spacing uniformity for sugar beet planters. *Appl. Engg. Agric.*, **16**(1): 7-13.

Raheman, H. and Singh, U. (2003). A sensor for seed flow from seed metering mechanisms. *J. Institute Engg*., **84** : 6-8.

Shaw, L.N. (1997). Automatic transplanter for vegetables. *Proc. Florida State Hort. Soc.*, **110**: 262–263.

Singh, S. (2008). Research highlights. All India Coordinated Research Project on Farm Implements and Machinery, Central Institute of Agricultural Engineering, Bhopal (M.P.) INDIA.

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