चेक रौ प्लांटिंग के लिए सेंसर नियंत्रित बीज मीटरिंग तंत्र का डिज़ाइन और विकास

DESIGN AND DEVELOPMENT OF SENSOR CONTROLLED MECHANISM OF SEED METERING FOR CHECK ROW PLANTING

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DIVISION OF AGRICULTURAL ENGINEERING

ICAR–INDIAN AGRICULTURAL RESEARCH INSTITUTE

NEW DELHI–110 012

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DESIGN AND DEVELOPMENT OF SENSOR CONTROLLED MECHANISM OF SEED METERING FOR CHECK ROW PLANTING

A Thesis

By

MANJUNATH

Submitted to the Faculty of Post-Graduate School,
ICAR–Indian Agricultural Research Institute, New Delhi
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This is to certify that the thesis entitled **'Design and development of sensor controlled mechanism of seed metering for check row planting'** submitted to the Post-Graduate School, ICAR–Indian Agricultural Research Institute, New Delhi, in partial fulfillment of the requirements for the award of the degree of **Master of Technology in Agricultural Engineering**, embodies the results of *bonafide* research work carried out by **Er. Manjunath (Roll No. 20639)** under my guidance and supervision, and that no part of this thesis has been submitted for any other degree or diploma. The assistance and help availed during the course of investigation as well as source of information have been duly acknowledged by him.

Date: December, 2017

Place: New Delhi, India

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New Delhi

Dedicated to My Beloved

FAMILY

&

TEACHERS

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Chapter 1

INTRODUCTION

With the increasing urbanization and industrialization, day by day the agricultural land is decreasing so that there is need to produce more per unit land to meet the food and nutrition requirement of increasing population. Seeding or the planting is one of the most important critical farm operations in agriculture as it not only decides the crop stand and overall production of crops but also helps in judicious use of costly input. Creation of suitable plant spatial distribution is indispensable since it induces changes in micro-meteorology of crop canopy and has cumulative effect on yield.

The concept of check row planting originated in USA. The earliest mention of check-row planting is found in patent reports of 1840 (Anonymous 1998). Check row planting is method of planting in which row to row distance and plant to plant distance is maintained constant so that seeds are aligned in longitudinal as well as in lateral direction. Planting in check rows significantly helps to reduce in the weed population since this method allows weeding in both directions. With the sufficient space all around the crop, this method also helps in proper aeration and permitting sunlight up to the bottom of crop. The variability of labour availability during peak season of planting creates uncertainty and delay in planting which in turn results in lower yield. Thus it is necessary to mechanize to meet timely requirement. Precision planting is a prerequisite to obtain check row planting pattern and also it can save seeds and efficiently control the sowing depth, plant density and the plant to plant distance (Li *et al.*, 2013). The output of precision planting increases by 10% to 30% as compared to the conventional drill (Zheng, 2006).

Of late use of seed drill or planter is increasing for sowing operation. The seed-metering device is the key component of the seed drill or planter, properties of which directly influence service behaviour and sowing quality of the seed drill or planter. The fluted wheel is used as seed metering mechanism on most of seed drills in which seed rate and plant to plant spacing cannot be controlled which causes hindrance to mechanization of subsequent intercultural operations. Planter is advancement over the seed drills in which single seed or group of seeds are placed at a predetermined depth and the space interval. On planter vertical plate, horizontal plate or inclined plate type metering mechanism may be used for metering seeds in which allows individual seed metering accurately.

Although, in planter row-to-row and seed to seed distance is maintained, seeds are not aligned in transverse direction due to slippage between the wheel and ground, and chain instability result planting in poor quality (Saadat *et al.*, 2013). Moreover, the planting quality deteriorates with increasing planter travel speed, making mechanical ground wheel driven systems unsuitable for high speed planting, and limiting their productivity (Yang *et al*., 2016). Electronic controls may be widely used in seed metering to make the machines more efficient, compact and light and imparts the flexibility of operation. Incorporation of electronic components in the planter decreases the multiple and miss index and increases the quality feed index which are desirable factors for efficient planting operation (Kamgar, 2013).

Although check row planting is not popular in India, however long back Martin Robbins of USA was granted first patent for the check-row planter. The first commercial tractor mounted check row planter was manufactured by Dearborn Motor Corporation, Michigan, in which seed drop was activated by buttons or knots on a check-wire and these knots were provided at required plant to plant distance so that when knot stroked the V- shaped finger seed dropping was activated by trip lever but this check wire has to be shifted from one pass to another pass until the full field is covered which is very laborious and time consuming. In India, farmers are practicing manual dibbling methods viz. by using tagged rope, marking by datari, ridger and bund former which are very laborious and time consuming. The challenge of check row planting cannot be addressed until the precise seed metering is done in addition to ensuring desired crop geometry using sensor controlled seed metering system.

Thus, maintenance of uniform seed to seed spacing and bi-directional alignment of seeds, elimination of problem of ground wheel slippage and skidding as well, dropping of seed at regular intervals is must. In fact, electronically controlled seed singulation devices can address many of the inefficiencies experienced in a

Mechanically driven seed metering device and facilitate the check row planting with existing planters.

Keeping above in view a study on “Design and development of sensor controlled mechanism of seed metering for check row planting” was carried out with the following objectives.

1. To determine the crop and machine parameters in relation to check row planting
2. To develop and evaluate the sensor controlled seed metering mechanism for check row planting

Chapter 2

REVIEW OF LITERATURE

Precision seeding of crop is paramount importance to achieve optimum seed rate, good crop geometry, uniformity of seed placement and sound crop stand. The manual broadcasting of seed, without suitable machines, fails to achieve the goals of proper seeding and increased cost of cultivation. Design of a precision planter needs optimization of different design parameters including crop, machine and metering mechanism. The review of previous research work related to precision planting, concept of electronic planter, influence of crop, machine and operational parameters on the design of planters is presented under the following sub headings.

i. Effect of check row planting on growth and yield of crop
ii. Design parameters for planter
iii. Electronic based seed metering mechanism
iv. Performance evaluation of planters

2.1 Effect of check row planting on growth and yield of crop

Shukla *et al.* (2013) observed that plants under closer spacing of 60 x 60cm (S2) produced considerably more leaf area index, seed cotton yield, crop profitability, crop productivity over wider plant spacing (90 x 60cm), where as they recorded better lint index under wider spacing. However, wider spacing produced considerably better growth attributes viz.dry matter, CGR and RGR at 120 DAE and 150 DAE, respectively over closer spacing.

Selvakumar *et al*. (2015) investigated effects of spatial pattern and nitrogen scheduling on intercepted photo synthetically active radiation (IPAR), light extinction co-efficient (‘k’), leaf temperature (LT) and productivity of maize. Field experimental results indicated that maize canopy under 30 × 30 and 35 × 35 cm spatial pattern intercepted 10 to 15% more light compared to rectangular pattern (60 × 25 cm). The ‘k’ value and leaf temperature were reduced under this pattern. Maximum maize grain yield (GY) was recorded at 35 × 35 cm spatial distribution. The LCC based N scheduling recorded superior values of IPAR, LT and lower ‘k’ values. Square planting favoured canopy micro-meteorological parameters and which in turn enhanced grain yield of maize.

Kuttimani *et al*. (2016) conducted an experiment to assess the influence of System of Crop Intensification (SCI) practices in green gram. Yield attributes like number of clusters hill-1 (7.67) and number of pods hill^{-1} (38.00) was considerably better with double seedlings hill^{-1} maintained at 40 x 40 cm planting geometry than other levels. Whereas, pod length and 100 grain weight were not changed due to SCI practices. Double seedling hill^{-1} maintained at 20 x 20 cm spacing showed considerably better grain yield (1263 kg ha^{-1}) and it was on par with single seedling hill-1 maintained at 25 x 25 cm spacing (1207 kg ha^{-1}), single seedling hill-1 with 25 x 25 cm spacing (1207 kg ha^{-1}) and double seedlings with 30 x 30 cm (1117 kg ha^{-1}). Haulm yield was better under double seedlings hill^{-1} with 30 x 10 cm spacing (2746 kg ha^{-1}). The highest net return (16371) and B: C ratio (1.76) was obtained with double seedlings hill^{-1} maintained at 20x 20 cm spacing. Hence, it is concluded that under SCI in green gram (variety CO 6) raised at 20 x 20 cm spacing with double seedlings proved to be a better option for better productivity and profit under garden land condition of Western zone of Tamil Nadu.

Rajput A *et al* (2016) conducted field experiments to study the different crop geometries and depths of planting on growth and yield of rice in system of rice intensification. The results indicated that the 30 cm × 30 cm planting geometry had advantage in various parameters *viz*; growth parameter, yield and yield attributes, which were considerably influenced by plant geometry and depth of planting.

It would be prudent to investigate the effect of check row planting on growth and yield of crops as very less information is available for Indian conditions.

2.2 Design of metering mechanism for planters

Aware *et al*. (2004) designed an inclined plate metering mechanism for planting of peanuts. It consisted of a hopper, cell plate, ground wheel, electronic circuit, and the mounting frame. The designed electronic metering mechanism was tested with a forward speed of 1 km h^{-1} in the laboratory by using grease board. Average hill to hill spacing of 13.3 cm was reported, which was close to hill to hill recommended spacing of 13 centimetre.

Jayan and Kumar (2004) evaluated the physical properties of maize, red gram, cotton for design of metering system. They observed the roundness of maize, red gram, and cotton was 1.14 ± 0.14, 1.15 ± 0.10, and 1.26 ± 0.10, respectively, whereas sphericity was 0.621 ± 0.065, 0.750 ± 0.016, 0.550 ± 0.016, respectively. The bulk density varied from 613 to 648 kg/ m^3 and true density varied from 989 to 1000 kg/ m^3. The angle of repose varied from 19.2 to 26.3°. The static coefficient of friction of cotton seed was found to be, stainless steel (0.28 to 0.35), mild steel (0.38 to 0.43), ply wood (0.40 to 0.45) and rubber (0.43 to 0.46). Maximum breadth and length of seeds are used to design the thickness and cell diameters of the seed metering discs. Seed flow through the various components of the planter was influenced by roundness and sphericity.

Singh *et al.* (2005) designed a tractor operated pneumatic planter for planting cotton, groundnut and mustard seeds in black soil using metering disc with 120 degrees entry cone angle on 2.5 mm seed hole for cotton, 120 degrees entry cone angle on 4.5 mm seed hole for groundnut and 90 degrees entry cone angle on 1.5 mm seed hole for mustard seed, respectively. The entry cone angle of the hole was varied from 90 to 150^0, the speed varied from 0.29 to 0.69 m/s, and the vacuum pressure from 1 to 2.5 kPa. The metering system of the planter was set to place the seeds at 250 mm spacing. With this planter variability in seeds/plant spacing for cottonseeds (25.07 and 29.82 cm), groundnut seeds (10.05 and 12.36 cm) and mustard seeds (10.91 and 13.58 cm) obtained in the laboratory and field conditions, respectively.

Matin *et al.* (2008) evaluated power tiller operated inclined plate planter developed by BARI. The metering mechanism of the planter consisted of a seed metering plate with 10 cells and the metering plate was inclined at 30° to the vertical. The peripheral velocity of the plate was 0.15 ms^{-1}.

Shiddangouda (2011) studied the biometric properties of carrot seeds to determine the design values of different parts of seed metering mechanism such as cell size, cell diameter, thickness, hopper wall slope and material for metering plate and evaluated for three different cell shape (semicircular, triangular and slant), three different seed treatments (uncoated, biogas slurry, and thirame coated) at three inclinations of metering device(40°, 50° and 60°). The combination of design variables viz, 50° plate angle, slant cell shape performed better with 83.9 per cent quality of feed index, 20.9 per cent precision index, 6.11 miss and multiple indices.

Vasuki and Tajuddin (2015) designed the seed metering mechanism for the five varieties of cotton seeds which were suitable for high density planting system from the engineering properties of cotton seeds viz., size, sphericity, thousand seed mass, bulk density, angle of repose, coefficient of friction and true density. Cell size of the seed metering disc was designed with reference to maximum breadth, width and length of seeds. Sphericity ranged from 0.636± 0.016 to 0.687 ± 0.02 and thousand seed mass from 61.60± 0.089 to 93.6 ± 0.120 g. Capacity of seed hopper was decided based on the bulk density of seeds.

Most of the planters have horizontal plate, vertical plate and inclined plate type seed metering units which were driven by taking power from ground wheel. This type of metering units was not capable maintaining check row planting pattern due to the slippage of ground wheel. Therefore it was necessary develop an efficient metering unit which overcome the problem of ground wheel slippage and effectively singulate the seeds.

2.3 Electronic based seed metering mechanism

Jafari *et al.* (2010) developed a DC electric variable-rate controller for changing the conventional to variable rate seeder. The variable rate seed sowing was obtained by changing the speed of the seed meter drive shaft on-the-go with the help of DC motor and control system. The closed loop control system consist of encoders for sensing the rotational speeds of drive wheel and the motor, GPS receiver, a pulse-with-modulation (PWM) DC motor controller.The response time of the variable-rate(low to high) system in transition from 78.5 to 262.5 kg $ha^{-1}$was 7.4 s and the delay distance in transition from high-to-low is 2.7 m whereas the response time of the variable-rate (high to low) system in transition from 262.5 to 78.5 kg $ha^{-1}$was 5.2 s while the drill operated at a travel speed of $1ms^{-1}$. The increase in response time for the low-to-high rate change as compared with the high-to-low rate change was due to the increase in motor torque demand.

Singh and Mane (2011) developed an electronically controlled seed metering mechanism for precision planter. It consisted of a proximity sensor, pulse generator, BCD counter (IC 4510), timer (IC 4093), relay unit, thumb wheel, DC motor and cup type seed metering unit. The electronic circuit controlled the operation of the DC motor which in turn rotated the metering unit to deliver the seed. Performance of the developed metering mechanism was evaluated in the laboratory using greased belt technique for okra seed with different levels of seed to seed spacing and forward speed of operation. The miss and multiple indexes were zero. Seed placement was more accurate at slower speeds and larger target seed to seed spacing.

Aware and Aware (2014) developed a microprocessor based electronic metering mechanism for three row cowpea planter. The ground wheel speed of planter was sensed by opto electric sensor. The output of the senor connected to DC motor which drives the seed metering plates. The metering unit is evaluated on lab and observed deviation from actual & theoretical spacing was 1.2cm because under variable loading conditions the D.C. motor does not rotate at the rated speed.

Yang li *et al.* (2015) developed mechatronic driving system eliminated the effect of ground wheel slippage on planting quality and maintain the uniformity of seed distribution on conventional precision corn planter. It was observed that Quality of Feeding Index(QFI), missing index and precision index increased with the increase of forward speed, with the values of 89.93%, 5.08% and 18.92% respectively at highest forward speed of 12 km/h. The mechatronic driving system reduced the effect of forward speed on planting accuracy effectively.

Cristian Iacomi and Octavian Popescu (2015) conducted a study which involves the process of designing, developing, and testing the feasibility of an apparatus used to precision place single seeds in a furrow during a planting operation. The equipment incorporated is a linear solenoid actuator connected with a special draw not used with any current seed metering device yet. The design uses an electronic device (based on 555 timer) to assist the solenoid in one movement (the forth movement of the draw), the back movement being accomplished by a spring. An optical electronic device was developed to trigger the 555 timer and the solenoid. This prototype gives a glimpse of what is possible in the future of seed singulation.

Kamgar.*et al.* (2015) designed an electrical seed metering unit for direct seeding of wheat. The seeding rate was determined based on the calculated error signal and output signal of the digital encoder of the supplemental ground wheel. The seed drill with designed electrical seed metering unit eliminated the effect of forward speed and stubble existence and also reduced the coefficient of variation (CV) by approximately 50%.

Rajaiah *et al.* (2016) developed an electronic experimental set-up to evaluate three seed-metering mechanisms, viz. slanting, semicircular and rectangular shape for three paddy varieties and to investigate the influence of the selected levels of variables, viz. forward speed, cell shape and inclination of seed-metering plate on performance parameters of seed metering. The mean seed spacing of 14.8 cm close to theoretical seed spacing of 15 cm, highest quality feed index of 88.1%, lowest miss index of 6.1% and minimum seed damage of 0.38% were observed in slanting type metering plate at an angle of 35º with the horizontal and at a forward speed (belt speed) of 2 km/h. Hence, for design of precision paddy planter, the optimum parameters, like slanting type metering plate with angle of inclination 35º and forward speed of 2 km/h can be used to achieve best results

He *et al.* (2017) designed an electric-driven control system for the seed meter of a precision planter to avoid the issues of poor planting quality and low travel speed limitations associated with conventional ground wheel and chain driven planters. A closed-loop proportional-integral-derivative (PID) algorithm was deployed to control the seed plate rotation speed. The performance of three PID tuning methods (Ziegler-Nichols step response method (ZNM), Cohen-Coon method (CCM), and Chien–Hrone s–Reswick method (CHRM)) was compared by Matlab-Simulink simulation, and results testified that the CCM had a better performance with smallest rise time of 0.018 s, settling time of 0.082 s and maximum overshoot of 26.1%. Field experiments revealed that a four-row planter equipped with electric-driven control system had considerably better quality of feed index (QFI), miss index (MI), and precision index (PREC) values as of with a ground wheel and chain driven planter under same working conditions. For a travel speed of 8.6 km/h, the mean values of the four rows for the QFI, MI, and the PREC were 98.62%, 1.29%, and 14.51%, respectively. For a maximum travel speed of 13.0 km/h, the mean QFI still achieved a value of 97.09%.

According to above studies electronic seed meters effectively eliminate non-uniformity of seed spacing caused by slippage of ground, therefore increase working speed and improve planting accuracy. Although Most of the above electronic seed meters are based upon concept of ground wheel speed synchronization. Therefore there is need to develop alternative electronic system which can work from single reference line and maintain plant spacing both in longitudinal and transverse direction that may help to achieve check row planting pattern.

2.4 Performance evaluation of planters

Sahoo and Srivastava (2000) evaluated the performance of a prototype planter to plant soaked okra seeds. The machine had a modular hopper and an inclined plate type metering unit. The power transmission to the metering unit was through a ground wheel by chain and sprocket system. The machine had a provision for varying row spacing and depth of seed placement. Based on the laboratory and field trial of machine it was concluded that the deviation of seed discharge among the rows from average for half hopper, three-fourth hopper and full hopper were within the range of 7% and was statistically insignificant. The maximum deviation of seed discharge for any of the row was 3.85 per cent. An average field capacity of 0.20 ha $h^{-1}$was observed for continuous operation of okra planter at an average speed of 2.27 km h^{-1}. The field efficiency and field machine index were found to be 66.5 and 77.38 per cent. Also there was a saving of 77 man hours per hectare and 76 per cent in cost of operation

Moody *et al.* (2003) evaluated the seed placement accuracy of inclined plate cotton planter at three seed meter rotational speeds of 0.16, 0.23 and 0.31 ms^{-1} with corresponding ground speeds of 4.8, 7.2 and 9.7 km h^{-1}. The observed quality of feed index ranged from 76.2 to 91.4%. The maximum standard deviation of normally sown seeds was 6.1 cm. They concluded that the variability in seed spacing increased with increasing seed meter rotational speed.

Matin *et al.* (2008) evaluated power tiller operated inclined plate planter developed by BARI. They reported that the average field work rate capacity of the unit was 0.19 ha h^{-1}. The unit resulted in a saving of 32.8 and 79.2 per cent saving in cost and labour respectively over traditional practice.

Shaaban (2009) conducted soil bin study to develop a prototype vacuum precision seeder suitable for onion seeds. The selected parameters were three seed plates with different hole diameters (0.8, 1.0 and 1.2 mm), four levels of peripheral velocity, 0.08, 0.14, 0.21 and 0.28 m/s, four levels of blower speeds, 4000, 4500, 5000 and 5500-rpm and three level of forward speeds, 2.7, 3.6 and 5.3 km h^{-1}. The observed optimum values of the actual seed spacing, 5.93 mm, seed miss index, 8.1%, seed multiple index 8.12%, quality of feed index 83.7% and precision in spacing 23.4%, respectively.

Onal *et al.* (2012) conducted a sticky belt experiment in the laboratory to investigate seed spacing accuracy for cotton and maize seeds. The sticky belt tests were performed at 0.10 and 0.20 m seed spacing for maize while the seed spacing for cotton was 0.05 and 0.10 m at forward speeds of 1.0, 1.5, and 2.0 m s^{-1}. It was found that the forward speed of either 1.0 or 1.5 m s^{-1} acceptable for cotton for the seed spacing of 0.05 and 0.10 m, respectively. The performance indices, namely the quality of feed, and miss and multiple indices, reduced significantly for cotton and maize seeding when the precision metering unit was run at 20% (11°) slope to the right as compared to the no slope condition.

Yasir *et al.* (2012) conducted a study to apply the precision metering on wheat seeding. The results showed that the rotating speed and negative pressure and their interactions had a considerable effect on seeding. The maximum quality feed index (92.98%) was obtained at rotating speed of 19.0 rpm and negative pressures of 2.5 kPa with multiple index and miss index of 2.01% and 5.09%, respectively. However, the seed rate (kernels per meter length) was less than the recommended compared to previous hypothesis. The better seed rate was 53 kernels per meter length producing quality feed index of 89.11% with multiple index and miss index of 9.00% and 1.88%, respectively at rotating speed of 34 rpm and negative pressure of 4.5 kPa. The recommended seed rates measured at 40 kernels per meter length and 53 kernels per meter length for 12 cm and 15 cm row spacing respectively were achieved at a range of rotating speed and negative pressure with quality feed index ranging between 84.57 to 89.11 per cent.

Dixit *et al.* (2011) evaluated a tractor operated inclined plate and pneumatic planter in the field on cotton variety LH-1556. It was found that the plant to plant spacing with pneumatic planter was 44 cm (recommended 45 cm), the average number of missing hills per 10 m length was 0.33 and percentage of doubles was 4.35 whereas in case of inclined plate planter, plant to plant spacing was 36 cm, average number of missing hills per 10 m length was 1.33 and percentage of doubles was 9.64. It was also found that with the pneumatic planter, number of hills with two or more plants was negligible. The observed capacity of pneumatic planter was 0.49 ha h^{-1} and that of inclined plate planter was 0.35 ha h^{-1}.

Singh *et al.* (2012) conducted experiment on performance evaluation of mechanical planters for planting of chickpea and pigeon pea and concluded that commercial sowing equipments meter high and non-uniform seed rate causing thinning as an extra operation. The missing and multiple seed percentage were 15.3% and 7.7% for commercial bed planter as compared to 27.2% and 9.1% in CIAE inclined plate planter, respectively. Uniform depth of seed placement was obtained for both the planters which were within the permissible range of 50-60 mm for chickpea and pigeon pea.

Sharma *et al*. (2013) developed the improved prototype Bt cotton planter and compared its performance with existing inclined plate type cotton planter. The effective field capacity of both machines was 0.73 and 0.71 ha h^{-1} at average operating speeds of 4.1 and 3.8 km h^{-1}, respectively. Time lost in turning of both planters was 35 and 37 sec/turn and the field efficiency was 59.34 and 58.77%, respectively. The mean plant spacing was 71 .8 cm and quality of feeding index was 75.57% in case of improved Bt Cotton planter whereas, the mean spacing of 77.6 cm and quality feeding index 68.81 % was recorded in inclined plate type planter. The missing index and multiple index recorded in improved Bt cotton planter were 15.45 % and 8.88%, respectively, whereas it was 22.86% and 8.33% in inclined plate type planter.

Kankal *et al* (2016) A single row manual cotton planter was evaluated for performance by conducting laboratory and field tests. The three trials of planter were taken for planting Bt-cotton crop. The rate of work was observed in the range of 0.18 to 0.21 ha/h at forward speed of 2.24 to 2.5 km/h in well prepared seed bed. The average depth of planting was observed in the range of 4.5 cm to 5cm. The field efficiency of the planter was observed in the range of 88.88 to 91.1 per cent.

Gautam *et al* (2016) developed and evaluated the inclined plate seed metering device in laboratory for singulation and uniform placement of onion seeds with different pelleting ratio viz. 1:1, 1:2 and 1:3 pelleted. It was evaluated for 40°, 45°and 50° inclinations, and 18, 24, 30 altered groove numbers on cells. The highest quality of feed index of 84 per cent obtained with seed metering plate of 24 grooves and 45° inclination angle at a forward speed of 2 km/h.

The developed planter were evaluated based on performance parameters viz., quality of feed index, missing index, multiple index, mean spacing. However, little emphasize was given to develop performance parameters for the check row planting pattern. There is need to develop suitable evaluation pattern for the check row planter.

From the above review of literature, it is clear that check row planting greatly affects the crop growth and yield. Check row planting leads to increased photosynthetic activity due to better sunshine received by the crop. With the check row planting the mechanization of subsequent operations become easy due to uniform crop spacing in longitudinal and lateral direction. In spite of these advantages of check row planting, a very less efforts have been directed for design of check row planting system. A number of efforts have been directed to develop electronic based precision planting system. The performance evaluation results of planters revealed the increased precision of electronic based planters. However, this precision with the electronic metering based planter is restricted to a particular row and does not confirm to the parallel row planting due to non existence of reference point. With the advancement of electronic based metering system the use sensors for check row planting seems to be the viable option.

Chapter 3

MATERIALS AND METHODS

The check row planting has several advantages over normal planting. Based on the information gathered from the review of literature, it was clear that no significant research has been directed towards this topic. The seed metering system should possess ability to accommodate different varieties. Planting in check rows needed the development of a metering system that can guide the dropping of seed at regular intervals of time and at the same instant maintain uniform bi directional spacing hence to obtain the desired level of accuracy and precision, electronic components was required. The study of crop and machine parameters was necessary for the design and development of seed metering system. The materials used and methods followed including design procedure are presented in this chapter under the following sub headings.

1. Determination of physical and engineering properties of green pea
2. Selection of design parameters
3. Design and development of sensor controlled seed metering unit
4. Plan of experiment for design parameters
5. Performance evaluation of developed mechanism
6. Statistical analysis of data

3.1 Physical and engineering properties of green pea

The physical and engineering properties of two green pea varieties (Plate 3.1) seeds i.e. size, shape, bulk density, angle of repose and 100 grain weight that affect the seed metering performance, were determined for designing of seed metering unit. The size of seeds was important in designing groove length, depth and number of grains to be required over groove surface of seed metering mechanism. The shape of seeds affects the uniform free flow of grains from the groove surface. Bulk density and true density were important for the designing seed hopper. Angle repose and coefficient of friction was required to decide slope for free flow of grains from the hopper. Coefficient of static friction values as measure of resistance was studied to decide the selection hopper material for uniform and free flow of grains, while the

100 grain weight was used to determine the number of grain required per meter of area for a desired seed rate. The physical properties determined are as follows:

a **b**

Plate 3.1 Two varieties of green pea a. PUSA SHREE b. PUSA PRAGATI

i) Size and shape

The size and shape of seeds were the two important factors that helped in deciding shape and size of seed metering unit. Size of seeds was measured as major and minor diameter.

Sphericity (ϕ) affects the uniform free flow of green pea grains from the metering plate groove surface. In order to define the shape of seeds, sphericity (ϕ) was calculated by utilizing the values of physical dimensions of seed using the following relationship.

$$\text{Sphericity } (\phi) = \sqrt[3]{\frac{l \times b \times t}{l}}$$

ii) Bulk density

Bulk density and True density values are used to design the seed hopper (Waziri and Mittal 1983). Bulk density was determined using a cube of size 115x115x115 mm. The cube was filled with grains without any compaction, and later on the seeds filling the cube were weighed. The bulk density was using the following relationship

$$\text{Bulk density, kg/m}^3 = \frac{W}{V}$$

Where,

W = weight of the sample, kg

V = Volume of the sample, m^3

iii) Angle of repose

The angle of repose was determined by allowing the seed to fall freely on to a horizontal surface to form a heap cone. The diameter of the base circle so formed by the heap of the seed and its height were measured and angle calculated by the following equation (Dutta, *et al* 1988).

$$\emptyset = \tan^{-1} \frac{2h}{d}$$

Where,

Ø = angle of repose, deg

h = height of the heap, cm

d = diameter of the base plate, cm

iv) 100 seed weight

The factor for deciding the desired seed rate of grains was one hundred seed grain weight. Five samples each of one hundred seeds were randomly selected from the seed samples of two varieties and weighed using an electronic balance and mean weight was determined.

3.2 Selection of design parameters

For the development of precise seed metering mechanism for check row planting, the crop and machine parameters were studied. A metering device for efficient design of planter was designed to meet the expectations of farmers.

3.2.1 Crop parameters

The crop parameters play a vital role in the design of planters. The crop parameters considered for the design precise seed metering mechanism for check row planting were. Two varieties of green pea (Pusa Pragati and Pusa Shree) were selected for design of metering system and the following crop parameters were selected.

i) Row to row spacing, m

ii) Plant to plant spacing, m

iii) Number of seeds per hill

Since in check row planting the plant to plant and seed to seed distance are equal, therefore three different check row spacing viz., 30×30 cm, 40×40 cm, 50×50 cm and the number of seeds per hill were taken as 2 to evaluate the seed metering system..

3.2.2 Machine parameters

In the present study a LIDAR proximity distance sensor was used to actuate the seed metering rotor which was rotated inside the stationary seed plate when the desired plant to plant spacing was achieved by forward movement. Hence, as the coefficient of friction of rotor and the seeds decides cell fill and singulation. Also to know there effects on quality feed index, multiple index and miss index the following variables were selected for achieving precision seeding of crop as evaluated through the recommended precision performance parameters.

i. Forward speed of operation

ii. Type of material of rotor

i) **Forward speed of operation**

The performance of a planter depends upon the forward speed of operation which affects the precision parameters like spacing, quality feed index and seed damage. To determine the optimum forward speed, the evaluation for selected performance parameters was carried out at 0.5, 0.65, 1.3, km h^{-1} speed levels.

ii) Type of material of the rotor

In the present study seed plate was held stationary, and the metering rotor was rotated inside the seed plate. The metering plate was housed in a cylindrical seed hopper. The seeds from the cylindrical bulk hopper flows to the cone shaped groove on to the seed plate. The seed was carried from cone shaped groove to the outlet by rubbing and rolling action due to the friction between seed and periphery of the rotor. The coefficient of friction of rotor affects the cell fill therefore two different types of rotor materials having different coefficient of friction were used viz., polyurethane rubber and polyurethane foam to evaluate the system.

iii.) Check row spacing

The plant to plant spacing was maintained through programmed micro-controller connected to the stepper motor which controlled the peripheral speed of seed rotor. It had influence on the quality of feed index, multiple index, and miss index. Therefore three levels of spacings viz., 30×30 cm, 40×40 cm and 50×50 cm were selected to evaluate the system.

3.3 Design of seed metering mechanism

Seed metering unit is the key component of the planter which influence the performance parameters therefore design of efficient metering mechanism is very important. The design procedure and components of seed metering unit were as follows.

3.3.1 Seed plate

The seed plate was designed based on the physical and engineering of green peas. The mean value of lowest minor diameter 5.25 mm was used to design the cone shaped groove on seed plate. The Front, Side, Top and Isometric view of designed seed metering plate is shown in Fig 3.1.The designed seed metering plate was printed using 3D printer (Plate 3.2)

3.3.2 Seed metering rotor

The coefficient of friction of the rotor material was important which helps in seed rolling action therefore two types of rotor material was selected having different frictional properties. Polyurethene foam and polyurethene rubber were used as rotor material of density 2.65×10^{-4} g/cc and 7.55×10^{-4} g/cc, respectively (Plate 3.3). It was driven through stepper motor shaft which has three fins around its periphery each at 120° angle so that it gives firm grip to rotate the rotor without slip. It rotates gently, separates and meters the seed without damaging. The diameter and thickness of seed metering rotor was 80 mm and 30 mm respectively.

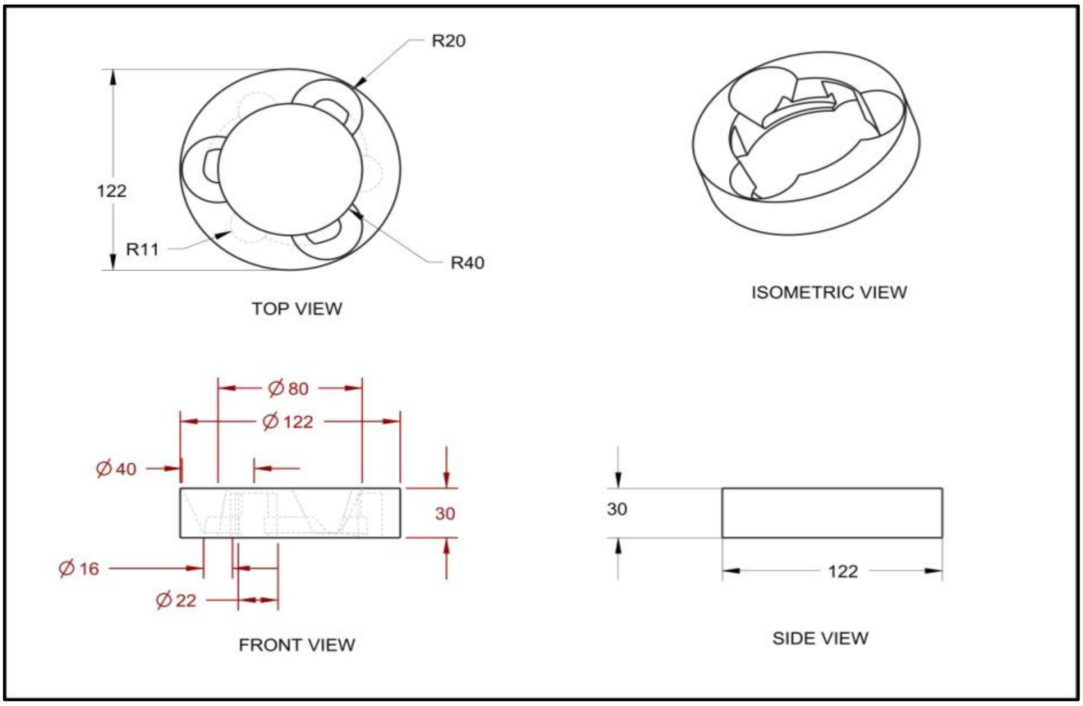

Fig 3.1 Design of seed plate

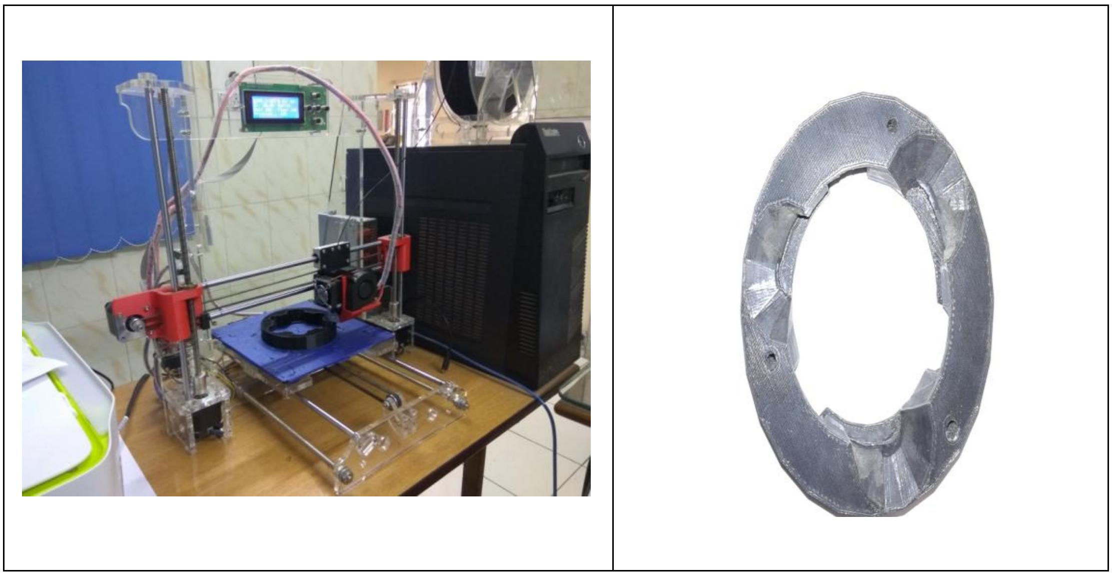

Plate 3.2 Fabrication of seed plate in 3D printer

a **b**

Plate 3.3 Two types of rotor material a. Polyurethene foam b. Polyurethene Rubber

3.3.3 Assembly of seed plate, rotor and stepper motor

The seed metering assembly consisted of sponge rotor, seed plate and stepper motor as shown in Plate 3.4. When programmed distance was reached by the forward movement of set up, the stepper motor drives seed metering rotor inside the seed plate. As metering rotor rotated, it carried each seed along its periphery to the outlets due to rubbing/friction between the rotor and seeds, and finally seeds were delivered to the seed tube via seed plate outlet.

3.4 Development of Sensor controlled seed metering mechanism.

Precision planting is the art of placing a single seed at defined spacing and controlled planting depth in the row to create an environment for a crop to facilitate easy intercultural operations (Kepner *et al.,* 1978). Electronic control systems provide high accuracy and adaptability, and can accommodate travel speeds as high as 15 km/h (He *et al*, 2017). Hence, an attempt was made to develop an electronic sensor controlled seed metering mechanism with following components.

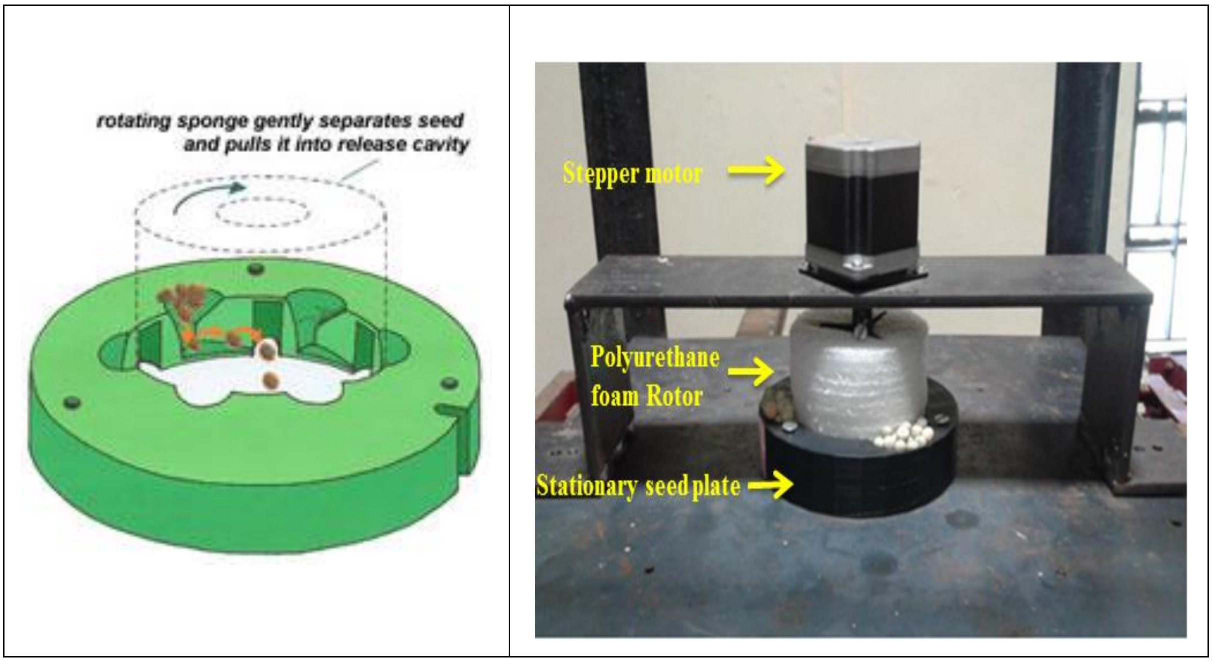

Plate 3.4 Experimental set up

3.4.1 Microcontroller unit

Arduino-UNO SMD R3 (Plate 3.5) board was used to take output of the LIDAR distance sensor and send input signal to the stepper motor when the programmed distance was reached. Arduino-UNO SMD R3 board was based on the ATmega328 microcontroller. It had 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, and a reset button. This board can be powered via the USB connection or with an external power supply at operating voltage of 5 volts. It was programmed with the Arduino software using the C programming language.

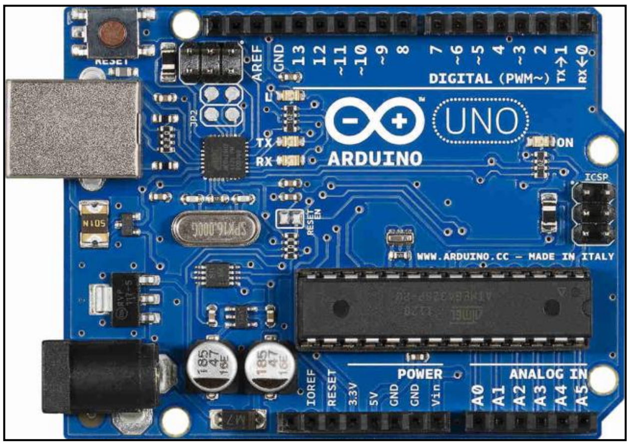

Plate 3.5 Arduino- UNO microcontroller unit

3.4.2 LIDAR distance sensor

LIDAR sensor was one of the main component of the system used to measure the distance between reference reflective surface and seed metering system (Plate 3.6). This device measures distance by calculating the time delay between the transmission of a Near-Infrared laser signal and its reception after reflecting off of a target. This translates into distance using the known speed of light.

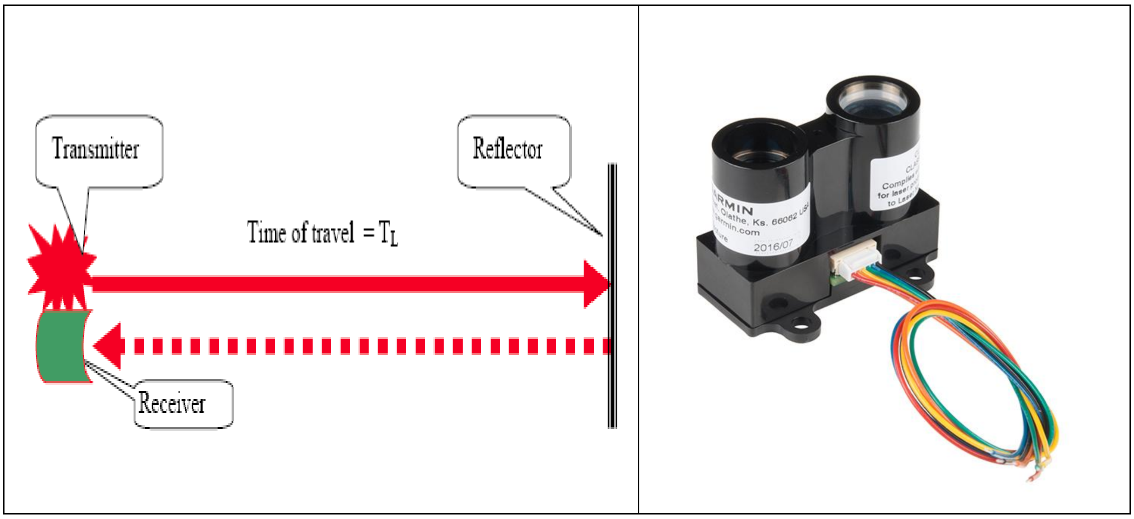

Plate 3.6 Operation of LIDAR sensor

The sensor was very compact, light weight and it works in wide temperature ranging from -20 t0 60°C. It operates on 5Vdc and has maximum range of 40m. In the present study wall was used as reference reflective surface. The sensor was interfaced using pulse width modulation (Plate 3.7). The sensor emits a near infra-red radiation of wavelength of 905 nm in pulsed form by transmitter at one side and receives it from another side through receiver after reflecting from the target. The sensor is connected to the Arduino as shown in the figure. The specifications of the sensor are given in Appendix B.

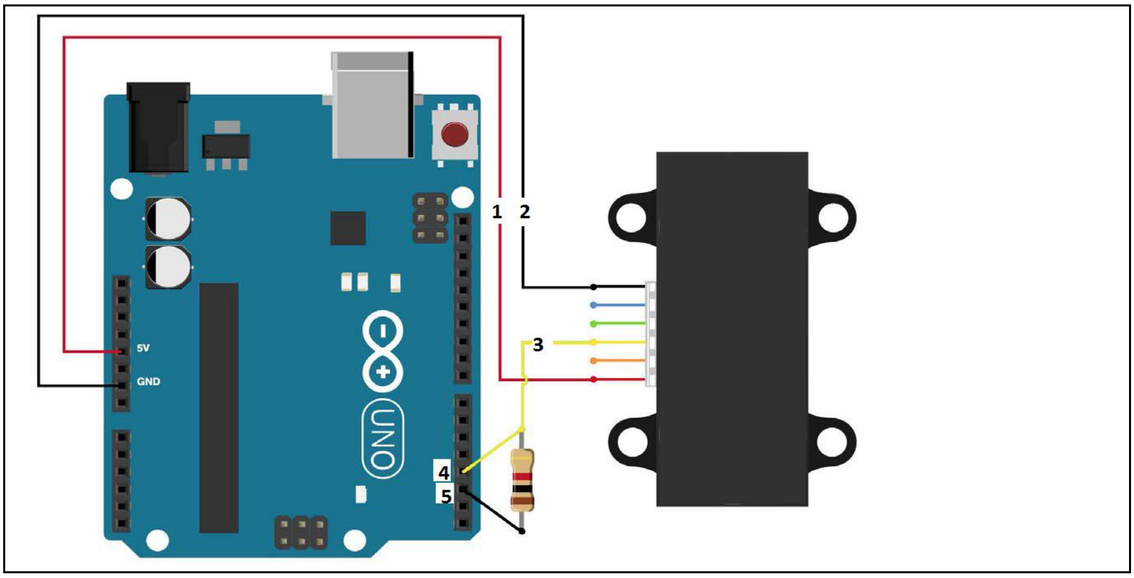

Plate 3.7 Interfacing of sensor with Arduino microcontroller

3.3.5 Stepper motor

Stepper motors are DC motors that move in discrete steps. The stepper motor Nema 23 (Plate 3.8 a) having torque of 10.1 kg-cm, operating voltage of 12-36V DC, step angle 1.8 deg / step, current 3.2A was used for driving the seed metering rotor.

3.3.6 Stepper motor driver

The motor driver is used drive the stepper motor at required steps and speed in definite direction by using 3A current and 12-36V (Plate 3.8 b).

3.3.7 Power Supply: The 12V-7Ah lead acid rechargeable battery is used to power the stepper motor (Plate 3.8 c).

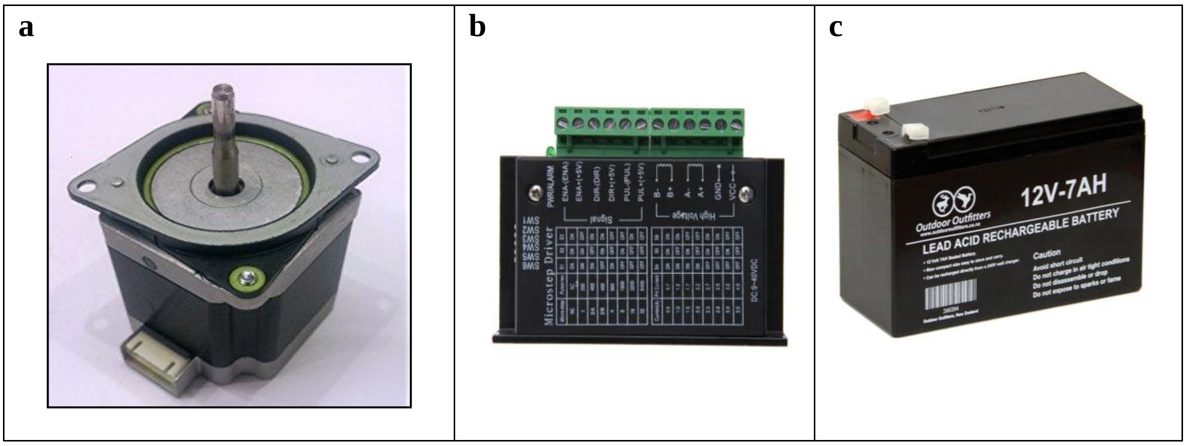

Plate 3.8 Electronic components used for metering unit a. Stepper motor a. Driver c. Battery

3.3.8 Seed tube

The seed tube of 25 mm diameter was fixed to the seed delivery outlet Plate (3.9). The height of tube was 500 mm and kept at an angle of 18^{o} to the vertical (RNAM 1995).The velocity of seed at the end of tube should be low to minimize bouncing and rolling of seeds in the furrow.

3.3.9 Furrow opener

Three hoe type furrow openers were fitted below the main frame in the front portion of seed metering unit to open the furrow (Plate 3.9). The furrow openers were fitted to the lower section of the main frame with brackets. The position of the brackets could be adjusted along the main frame to vary the row spacing. The rotor in the seed metering plate picks seed one by one and drops it through the outlet opening; from there seed was carried by gravity onto the opened furrow.

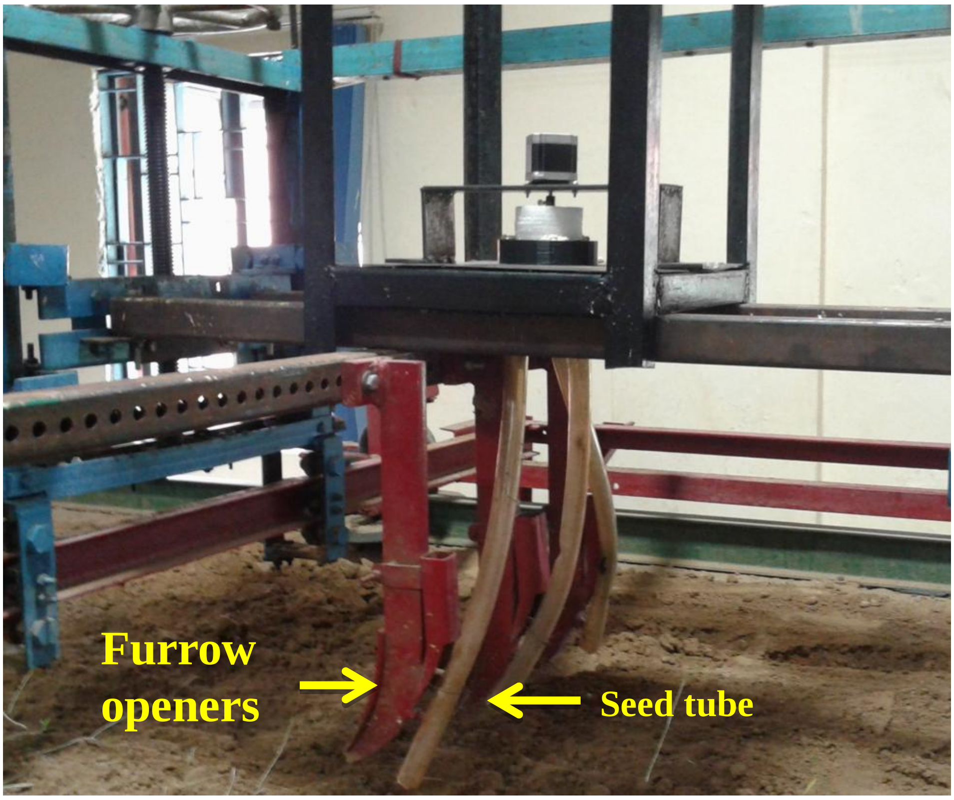

Plate 3.9 Furrow opener and seed tube attached to the main frame

3.4 Programming and circuit connection of controlling unit

.A program for Arduino Uno R3 was written in C programming language (Appendix A). The Arduino program follows the flowchart indicated in figure 3.3. A power of 5V dc is supplied to the LIDAR sensor through Arduino-Uno board and mode-control connection (Yellow wire in fig 3.4) was connected at digital pin 5 and a resistor of 1 kΩ connected at the digital pin 4 to the Arduino board as shown in fig 3.4. The circuit and structural diagram of the various components (Fig 3.5 and Fig 3.6).

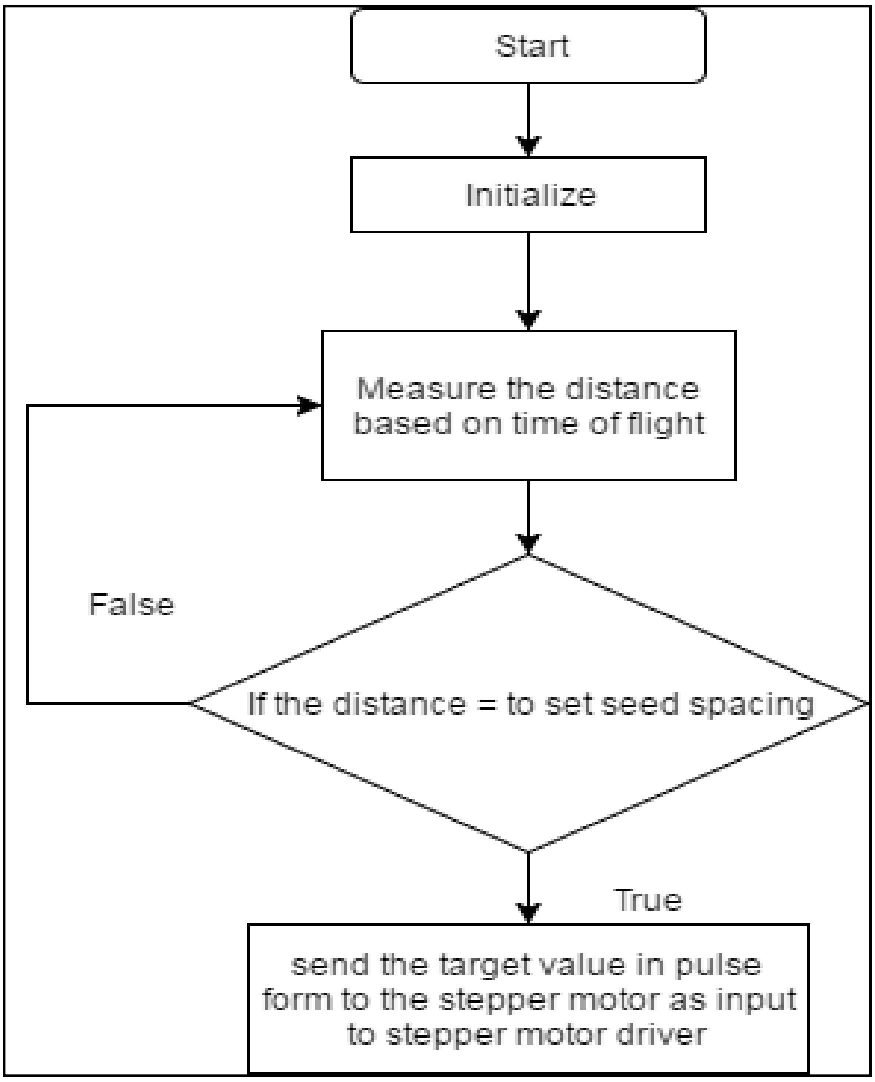

Fig 3.2 Flowchart of system and Arduino program to run the controlling unit

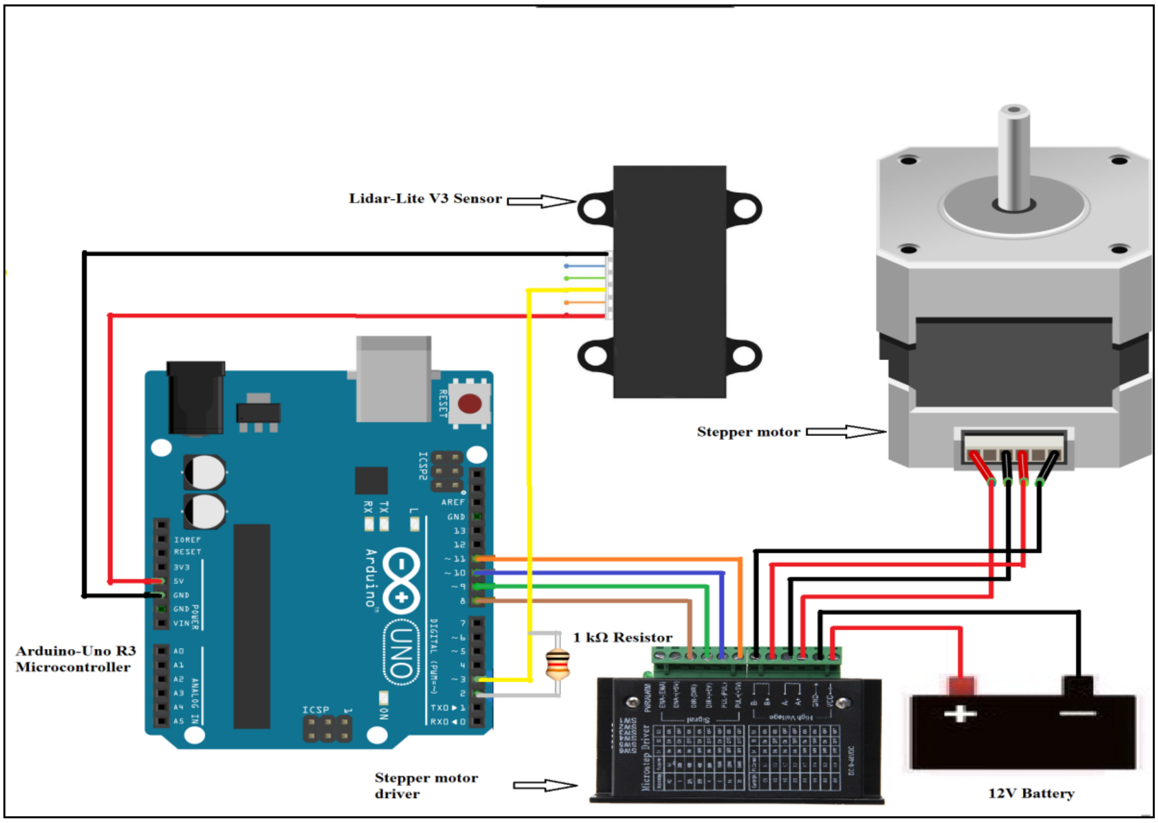

Fig 3. 3 Various components of the controlling unit

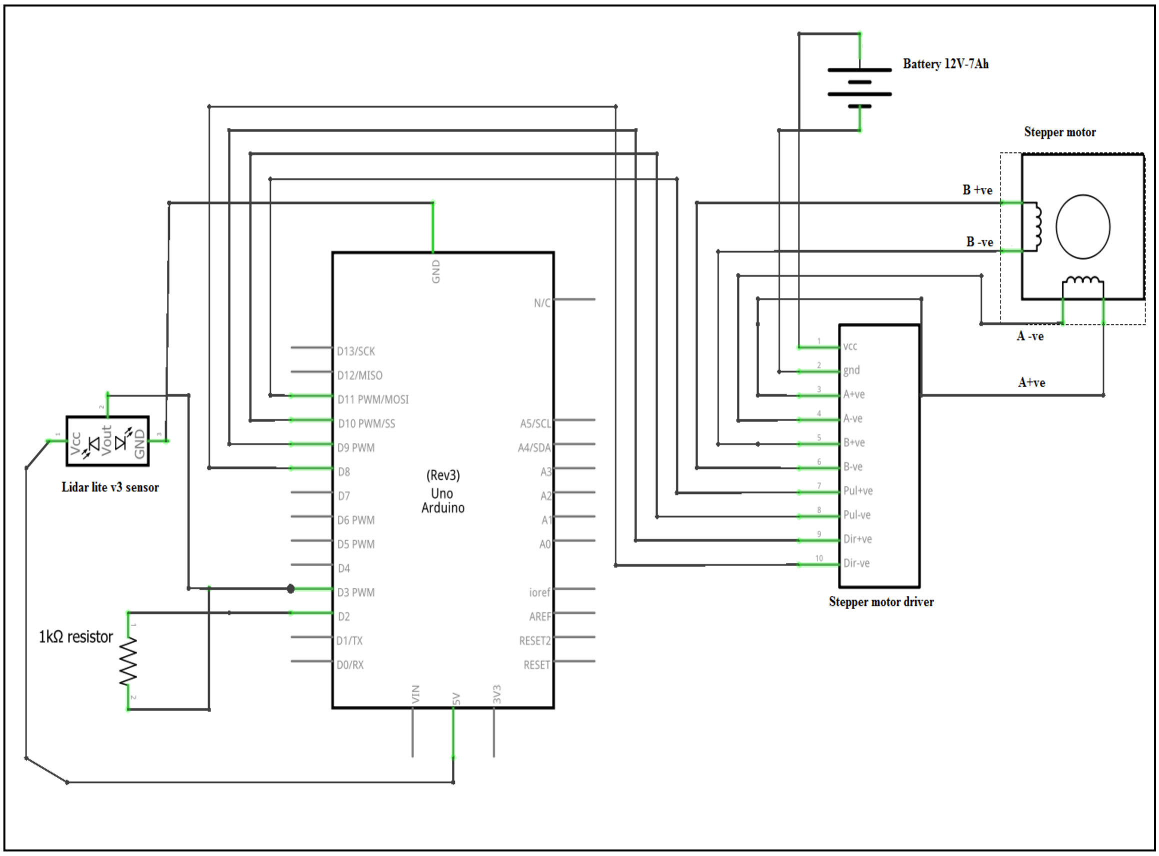

Fig 3.4 Circuit diagram of the controlling unit

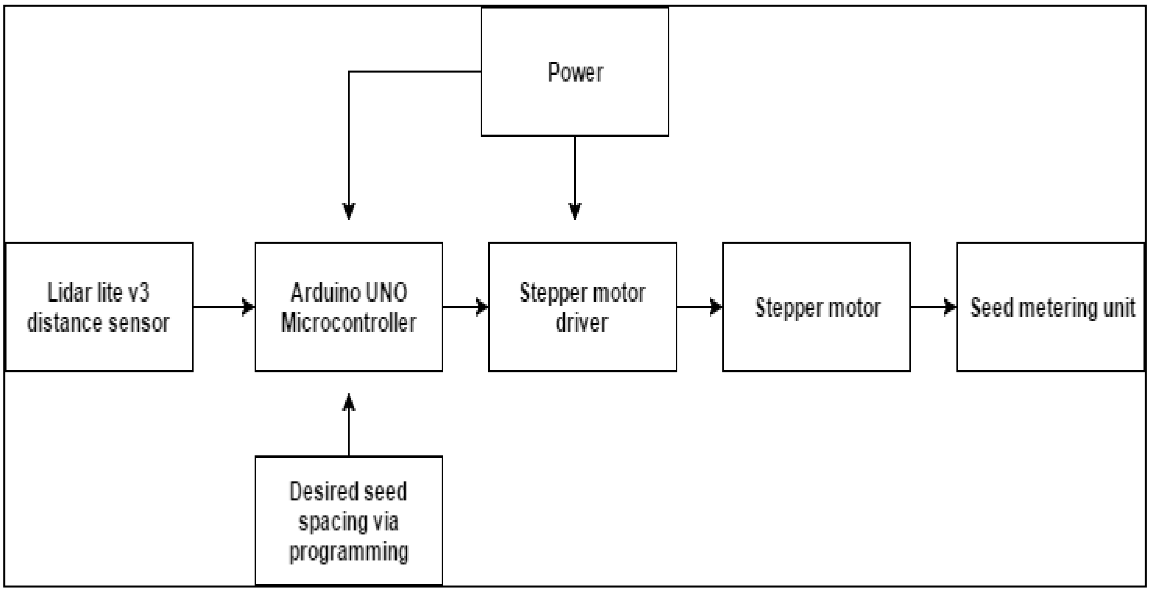

Fig 3.5 Structural diagram of the controlling unit

3.5 Working of sensor controlled seed metering mechanism

To achieve check row planting pattern, the metering system must maintain seed to seed spacing accurately in each pass apart from maintaining row spacing. The seed metering system was mounted on soil bin rail platform (Plate 3.10). The front wall of the lab was considered as reference reflective surface. When seed metering unit mounted on rail moves a forward distance which equals to programmed seed to seed spacing, the microcontroller send the target value in pulse form to the stepper motor. The seed metering rotor was fixed on the stepper motor shaft .The stepper motor rotated the seed metering rotor based amount of pulse received from the microcontroller. As the rotor rotated it picked up the seeds from the cone shaped groove of metering plate and delivered at outlets due to friction between seeds and periphery of the rotor .The outlets were connected to the seed tube and finally drops the seed in the furrow.

Plate 3.10 Sensor controlled check row plating system mounted on soil bin platform

3.5 Plan of experiment to optimize the number pulse to stepper motor for seed singulation

Independent variables	**Levels**	**Dependent variables**
Forward speed	3 (0.5 ,0.65 and 1.3 kmh^{-1})	Average number of seeds dropped from all three outlets
Number of input pulse	4 (50,60,70 and 80	
Type of material for seed metering rotor	2 (Polyurethene foam and Polyurethene Rubber)	
Replications	3	
Total No of Observations	72	

3.5.1 Experimental procedure

An experiment was conducted to optimize the number of input pulse to stepper motor to get correct singulation at different forward speeds and rotor material. Then experiment was repeated for another rotor material at different pulse inputs and different forward speed. The average number of seeds dropped in furrow from all three outlets for different pulse at different forward speeds were observed and recorded. Dropping of one seed from each outlet gave a mean value of one. The value of less than one indicated, less than two seeds are dropped out of three outlets while the value more than one indicated, more than three seeds are dropped out of three outlets. Therefore the desired value for correct singulation was to have a mean value of one. Based on this experiment number pulse required for seed singulation were optimized for different forward speeds and different seed metering rotor material. The optimized values of this experiment were used conduct the further experiment.

3.6 Experimental plan for study of performance parameters of sensor controlled seed metering mechanism in laboratory condition

Independent variables	**Levels**	**Dependent variables**
Forward speed	3 (0.5 ,0.65 and 1.3 kmh^{-1})	Seed rate, kg/ha Multiple index,% Quality of feed index,% Miss index,% Mean spacing, cm
Check row spacing	3 (30×30,40×40 and 50×50cm)	
Type of material for seed metering rotor	2 **(**Polyurethene foam Polyurethene rubber**)**	
Replications	3	
Total No of Observations	54	

3.6.1 Experimental procedure

The experiment was conducted on the soil bin platform as per the plan. Initially one rotor material was fixed and program was written in Arduino for one plant to plant spacing. The seeds were allowed to fall on the greased bakelite sheets and observations were recorded at varying forward speeds. These experiments were repeated with three replications. Similarly, other two plant to plant spacing were programmed to the microcontroller and it was evaluated at different speed. Again by changing rotor material similar experiment was conducted and observations were taken.

3.7. Determination of performance parameters

The performance parameters i.e spacing, quality feed index, seed rate, multiple index and miss index were evaluated at the selected levels of speed, rotor material and check row spacing. The desired values of evaluation parameters were calculated by following formula.

3.7.1 Mean Seed spacing

Average seed to seed spacing (m) = $\frac{\text{Sum of observed spacings}}{\text{Total number of observerd spacings}}$

3.7.2 Multiple index

Multiple index (D) is an indicator of more than one seed dropped within a desired spacing. It is the percentage of spacings that are less than or equal to half of the theoretical spacing:

$$D = n_1/N$$

Where,

N = Total number of observations, and

n_1 = Number of spacings in the region less than or equal to 0.5 times of the theoretical spacing.

3.7.3 Quality of feed index

Quality of feed index (A) is the measure of how often the seed spacing were close to the theoretical spacing (Kachman and Smith, 1995). It is the percentage of spacing that are more than half, but not more than 1.5 times the theoretical spacing.

The quality of feed index is mathematically expressed as follows:

$$A = n_2/N$$

Where,

N = Total number of observations, and

n_2 = Number of spacing between 0.5 times the theoretical spacing and 1.5 times of the theoretical spacing.

3.7.4. Miss index

Miss index is an indicator of how often a seed skips the desired spacing. It is the percentage of spacing greater than 1.5 times the theoretical spacing, and expressed as:

$$M = n_3/N$$

Where,

N = Total number of observations, and

n_3 = Number of spacings in the region >1.5 times of the theoretical spacing.

3.7.5 Seed rate

The seed rate for all the 54 treatments was arrived as detailed below. The seed rate is measured by using following equation.

$$\text{Seed rate}, \frac{\text{kg}}{\text{ha}} = \frac{\text{Total number of seeds collected in 5 m length bed} \times \text{Weight of 100 seeds,kg}}{\text{Length of bed,5m} \times \text{Number of furrow openers} \times \text{row to row spacing,m}}$$

3.8 Statistical analysis for optimizing design values

The effects of selected levels of variables on the evaluation parameters were analyzed using a statistical tool. The experimental data were analyzed using factorial completely randomized design. The statistical software SAS was used to analyze the experimental data. This was done to obtain the necessary analysis of variance of the mean and interaction of the selected variables *viz.*, forward speed, type of material for seed metering rotor and check row spacing as well as the dependent variables such as, quality of feed index, miss and multiple index.

Chapter 4

RESULTS

The physical and engineering properties of two green pea varieties (Pusa Pragati and Pusa Shree) were measured for determining design parameters of seed metering mechanism of check row planting. The number of pulse from the microcontroller to the stepper motor at different speeds was optimized for better singulation. Individual and interaction effect of selected levels of variables *viz.*, forward speed, different materials of seed metering rotor and check row spacing on quality feed index, multiple index, miss index, and seed rate was studied. The experimental results were statistically analyzed and presented as following:

4.1 Physical and engineering properties of green peas

The physical and engineering properties of green pea seeds measured for design of planter were size, shape, angle of repose, coefficient of friction and bulk density and the observations are presented as following.

4.1.1 Size and shape of green peas

The size of selected pea varieties was studied in terms of major diameter and minor diameter while shape was evaluated in terms of sphericity and aspect ratio. The observed values for the average major diameter, minor diameter of the green pea varieties were in the range of 5.25-7.88 mm, and 5.86-7.21 mm, for the variety Pusa Pragati and Pusa Shree, respectively (Table 4.1). The highest major diameter of 8.65 mm and lowest minor diameter of 4.84 mm was observed for Pusa Pragati (Fig 4.1).

Table 4.1 Variations in dimensions of selected green pea varieties

Variety	Descriptive Statistics	Major Dia (mm)	Minor Dia (mm)
Pusa Pragati	Range	7.32-8.65	4.84-6.02
	Mean	7.88	5.25
	CV(%)	1.53	3.21
Pusa Shree	Range	6.84-7.66	5.3-6.18
	Mean	7.21	5.86
	CV(%)	1.28	2.19

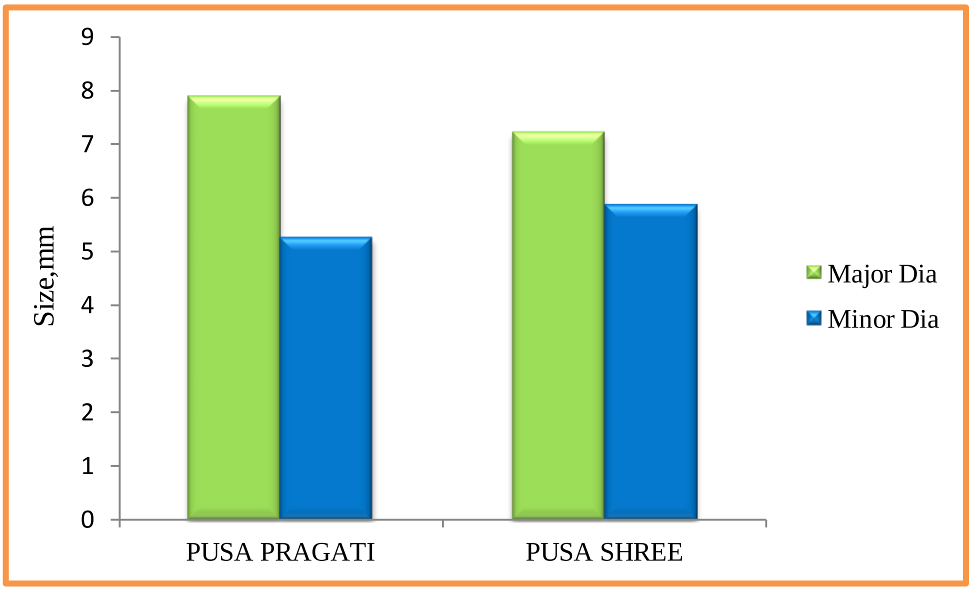

Fig. 4.1 Size dimension variations of green peas

The mean values of sphericity and aspect ratio for Pusa Pragati and Pusa Shree green pea varieties was in the range of 0.83-0.82 (Table 4.2) and 0.90-91, respectively. The sphericity closer to the value 1 indicated the spherical shape of selected seeds. The lowest sphericity value of 0.78 was found in case of Pusa Pragati and highest value 0.98 for Pusa Shree while the lowest aspect ratio value of 0.73 was observed for Pusa Pragati and highest value of 0.97 for Pusa Shree (Fig. 4.2).

Table 4.2 Variations in sphericity and aspect ratio of selected green pea varieties

Variety	Descriptive Statistics	Sphericity	Aspect Ratio
Pusa Pragati	Range	0.78-0.86	0.73-0.93
	Mean	0.83	0.82
	CV (%)	0.89	2.27
PUSA SHREE	Range	0.83-0.98	0.83-0.97
	Mean	0.91	0.90
	CV (%)	1.61	1.89

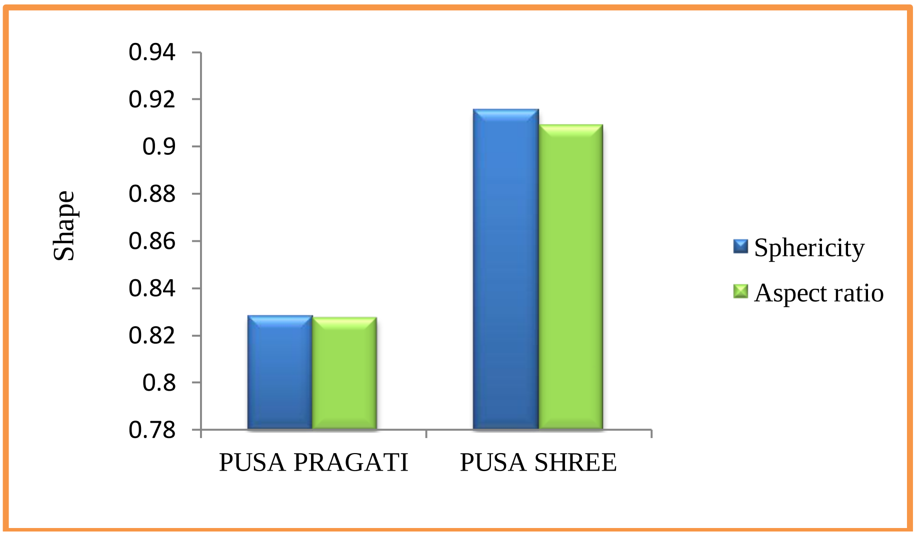

Fig. 4.2 Variations in sphericity and aspect ratio for green pea varieties

4.1.2 Angle of repose and coefficient of friction

The angle of repose for both the selected green pea varieties was found in the range of 21.07 to 26.73 degree. The minimum angle of repose (21.03^0) was observed for Pusa Shree while the maximum (26.73^0) was observed for Pusa Pragati. The mean value of angle of repose was found to be 25.87^0 degrees and 22.28^0, for Pusa Pragati and Pusa Shree, respectively (Table 4.3).

The mean values of coefficient of friction for Pusa Pragati with wood, MS and GI were found to be 0.46, 0.42 and 0.38, respectively while for Pusa Shree the mean values of coefficient of friction for wood, MS and GI were found to be 0.44, 0.38 and 0.31, respectively(Table 4.3 and Fig. 4.3). Over all, the coefficient of friction of selected pea varieties was least with GI as compared to Wood and MS.

Table 4.3 Variations in angle of repose and frictional properties of selected pea varieties

Variety	Descriptive Statistics	Coefficient of Static Friction			Angle of Repose
		Wood	MS	GI	
Pusa Pragati	Range	0.45-0.48	0.40-0.44	0.35-0.38	24.30-26.73
	Mean	0.46	0.42	0.35	25.87
	CV (%)	1.27	1.69	2.45	2.12
Pusa Shree	Range	0.43-0.45	0.37-0.40	0.30-0.33	21.03-23.96
	Mean	0.44	0.38	0.31	22.28
	CV (%)	0.99	1.87	2.08	2.77

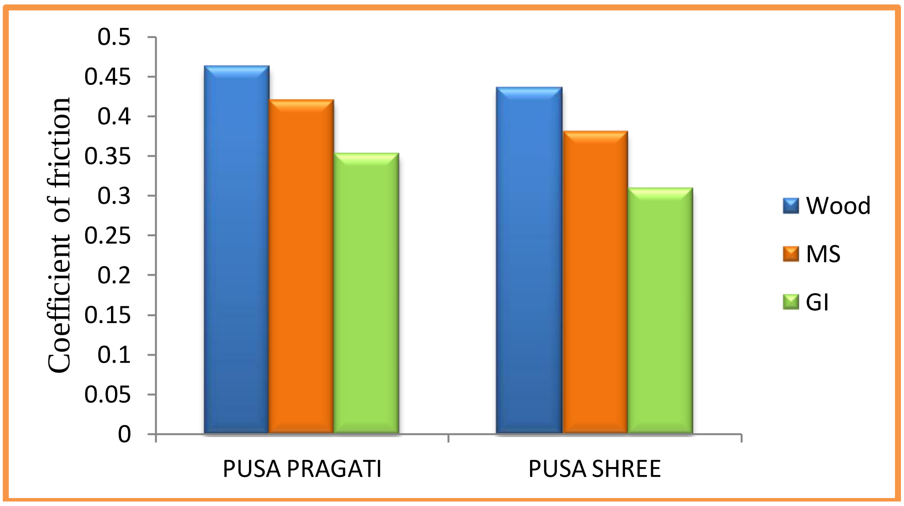

Fig. 4.3 Variations in coefficient of friction of green pea varieties

4.1.3 Bulk density

The bulk density of selected green pea varieties was measured and presented. The bulk density values of selected varieties were found to be in the range of 740.50 to 876.45 kg m^{-3}(Table 4.4). The lowest bulk density value of 740.50 kg m^{-3} was observed for Pusa Pragati variety and highest bulk density of 876.45 kg m^{-3} was observed for (Pusa Shree Fig 4.4). The mean value of true density found to be 1258.79 kg m^{-3} for Pusa Pragati and 1205.16 kg m^{-3} for Pusa Shree with the overall range of 1176.5 to 1273.88 kg m^{-3} (Table 4.4) for both the varieties. The 100 seed weight of both varieties of green peas was in the range of 17.20 g to 21.8 g having mean value of 17.63 g for Pusa Pragati and 21.22 g for Pusa Shree (Table 4.4). These values of bulk density, true density and 100 seed weight were used to calculate the hopper volume for a required design capacity.

Table 4.4 Variations in bulk and true density properties with variety

Variety	Descriptive Statistics	Bulk Density(kg/m^3)	True Density (kg/m^3)	100 Seed Weight(g)
Pusa Pragati	Range	740.50-765.43	1222.22-1273.88	17.20-18.33
	Mean	754.70	1258.79	17.63
	CV (%)	0.52	0.84	1.16
Pusa Shree	Range	856.30-876.45	1176.5-1234.5	20.30-21.8
	Mean	863.64	1205.16	21.22
	CV (%)	0.46	0.85	1.36

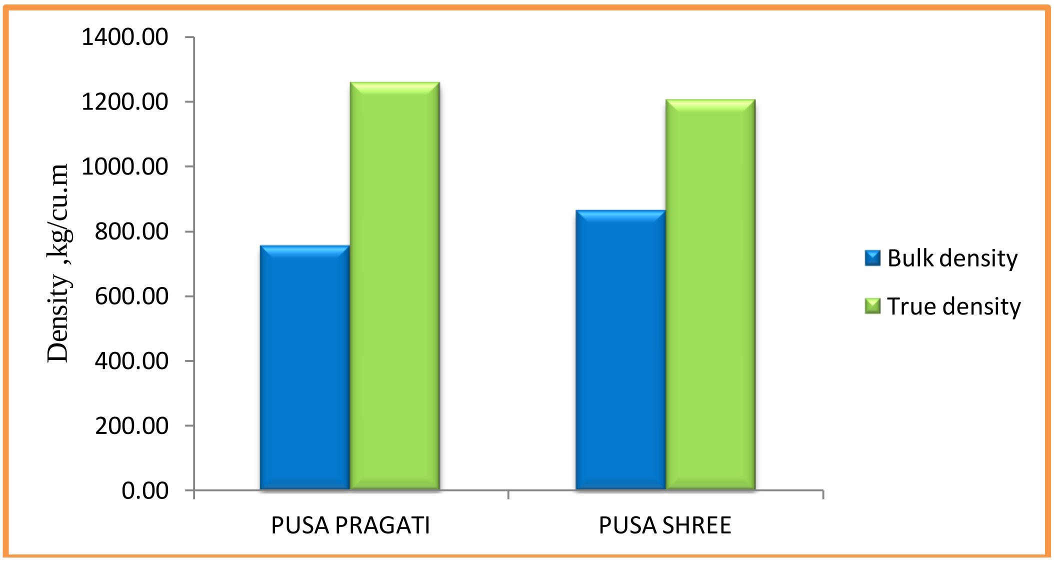

Fig.4.4 Variations in density parameters of green pea varieties

4.2. Effect of selected levels of variables on seed singulation

The singulation was significantly influenced by forward speed, type of rotor material and different number of pulse (Table 4.5). It was observed that 50 , 60, 70 pulses were required for polyurethane rubber at a forward speed of 0.5 kmh^{-1} , 0.65kmh^{-1} and 1.3 kmh^{-1} respectively to have a desired seed singulation value of one. While for polyurethane foam seed singulation of one was observed for respective pulses of 60, 70, 80 at a 0.5 kmh^{-1}, 0.65 kmh^{-1} and 1.3 kmh^{-1} respectively. The effect of speed, rotor and rotor material was found significant on seed singulation at 5% level of significance (Table 4.6). In general it was observed that for both the rotor materials, higher pulses are required for higher forward speeds to get the desired seed singulation value of one (Fig 4.5).

Table 4.5 Variations in singulation for different pulse input

No.of Pulse	Polyurethene Foam			Polyurethene Rubber		
	0.5 kmh^{-1}	0.65 kmh^{-1}	1.3 kmh^{-1}	0.5 kmh^{-1}	0.65 kmh^{-1}	1.3 kmh^{-1}
50	0.34	0.00	0.00	1.00	0.00	0.00
60	0.98	0.65	0.33	0.68	1.00	0.35
70	1.67	1.00	0.66	2.34	1.32	1.00
80	3.33	1.67	1.05	3.00	2.33	1.65

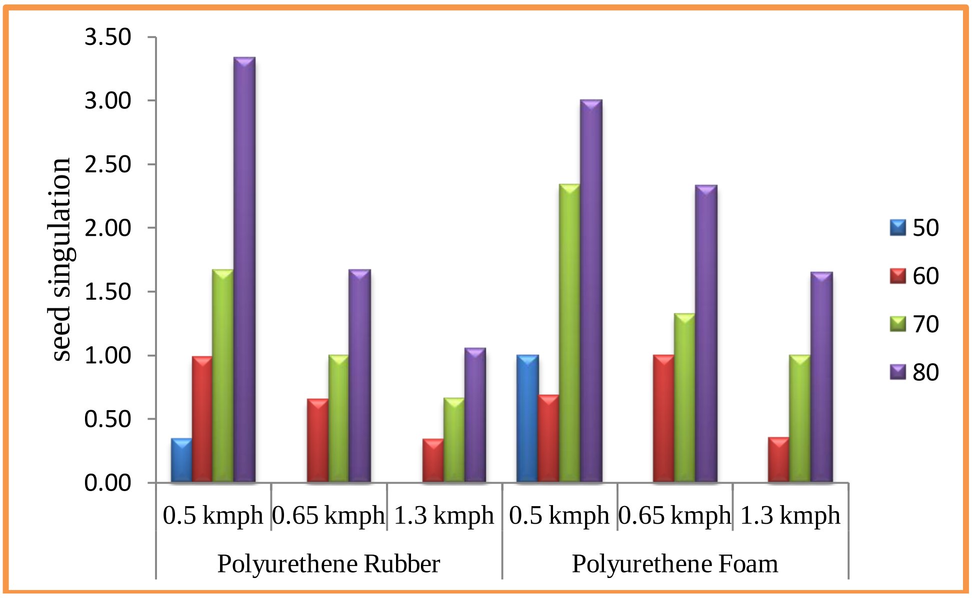

Fig.4.5 Variations in pulse input at selected levels

Table 4.6 ANOVA for the singulatioon at different pulse input and at different forward speed

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Factor R	1	1.13	1.13	6.23	0.02*
Factor N	2	13.36	6.68	37.00	0.00*
Int RX N	2	0.08	0.04	0.23	0.79
Factor S	3	38.71	12.90	71.46	0.00*
Int R X S	3	0.49	0.16	0.90	0.45
Int N X S	6	4.08	0.68	3.77	0.00*
Int A X B X C	6	1.81	0.30	1.67	0.15
Error	48	8.67	0.18		
Total	71	68.319			

*Note: * Significant at 5% level of significance*
R= rotor material, N= speed, S= Spacing

4.3 Effect of rotor material, forward speed and input spacing on the planter performance

A total number of 54 experiments were conducted in lab with selected levels of three variables. The performance of planting mechanism was studied in terms of quality feed index, multiple index, miss index, mean spacing and seed rate for all the treatments of the investigation. The observations recorded are presented as following:

4.3.1 Effect of forward speed, type of rotor material on mean seed spacing

The highest deviation of 7.88 cm was observed at 1.3 kmh^{-1} for theoretical spacing of 30 cm using polyurethane foam as seed metering material. The lowest deviation of -0.24 cm was observed at a speed of 0.65 kmh^{-1} for theoretical spacing of 40 cm using polyurethane rubber. The mean output seed spacing was found to increase with increase in speed. The highest seed spacing of 55.11 cm was observed for polyurethane foam at 1.3 kmh^{-1} forward speed for theoretical spacing of 50 cm (Table 4.7). This large variation was due to slippage between foam and the seeds at higher speed and also sensor might not have got sufficient time to sense the distance, due to which more skips happened. The mean seed spacing was significantly influenced by input spacing, forward speed, rotor material as well as their interaction at 5% level of significance (Table 4.8). In general, it was observed greater the forward speed, more was the deviation between theoretical and actual spacing (Fig 4.6).

Table 4.7 Mean spacing at different forward speed, type of rotor material and input plant to plant spacing.

Material	Theoretical spacing	Mean Spacing, cm					
		0.5 kmh^{-1}	Deviation	0.65 kmh^{-1}	Deviation	1.3 kmh^{-1}	Deviation
Polyurethene Rubber	30 cm	30.57	0.57	31.24	1.24	33.83	3.83
	40 cm	40.85	0.85	39.76	-0.24	43.17	3.17
	50 cm	51.63	1.63	51.58	1.63	53	3
Polyurethene Foam	30 cm	32.56	2.56	31.13	2.56	37.82	7.82
	40 cm	42.87	2.87	38.98	2.87	46.88	6.88
	50 cm	51.68	1.68	51.74	1.68	55.11	5.11

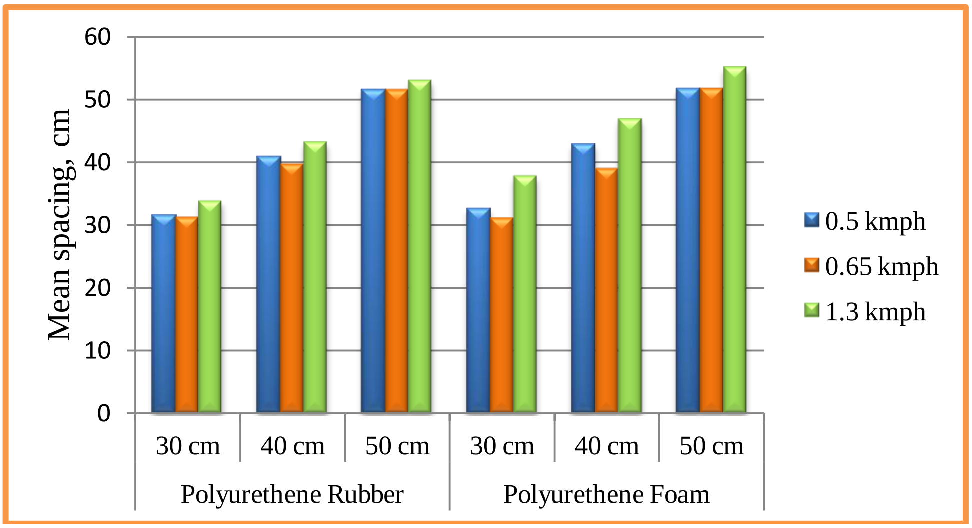

Fig.4.6 Variation in mean spacing at selected levels

Table 4.8 ANOVA for the mean spacing at selected levels

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Factor R	1	24.498	24.498	18.374	0.00013*
Factor N	2	172.961	86.481	64.862	0.00*
Int RX N	2	28.538	14.269	10.702	0.00023*
Factor S	2	3,403.589	1,701.795	1,276.379	0.00*
Int R X S	2	2.297	1.149	0.862	0.43104
Int N X S	4	19.458	4.864	3.648	0.01354*
Int A X B X C	4	4.413	1.103	0.827	0.51647
Error	36	47.999	1.333		
Total	53	3,703.754			

*Note: * Significant at 5% level of significance*
R= rotor material, N= speed, S= Spacing

4.3.2 Effect of forward speed, type of rotor material and input check row spacing on quality of feed index

The mean value of quality feed index at selected levels of variables viz., forward speed, type of rotor material, and check row spacing were determined (Table 4.9). The mean quality feed index was in the range of 80.30-85.94 per cent, 75.32-82.3 per cent for polyurethane rubber and polyurethane foam, respectively. The highest quality feed index of 85.94 per cent was observed at a forward speed of 0.65 km h^{-1} for polyurethane rubber at 40 × 40 cm input spacing. While, the lowest quality feed index of 75.32 per cent was observed at forward speed of 1.3 kmh^{-1} for polyurethane foam at 30 × 30 cm spacing for polyurethane rubber. The observed quality feed index (QFI) value at a forward speed of

0.5 kmh^{-1} was more than 85 % which was within acceptable limit as reported by Kachman and smith, 1995. Statistical analysis showed that the forward speed, angle of rotor material, and check row spacing significantly influenced the quality feed index at 5 per cent level of significance (Table 4.10). It was observed that the quality feed index decreased with increase in forward speed (Fig.4.7). This was probably because of the reason that at higher speeds sensor might not be getting sufficient time to actuate the stepper motor resulting in so more number of skips and hence decreased quality feed index.

Table 4.9 Quality feed index at different forward speed, type of rotor material and check row spacing

Material	Spacing	Quality of Feed Index		
		0.5 kmh^{-1}	0.65 kmh^{-1}	1.3 kmh^{-1}
Polyurethene Rubber	30 ×30 cm	84.72	84.2	80.82
	40×40 cm	85.47	85.94	80.3
	50×50 cm	85.57	84.45	81.17
Polyurethene Foam	30 ×30 cm	81.13	81.37	75.32
	40×40 cm	81.33	81.67	78
	50×50 cm	81.9	82.3	80.4

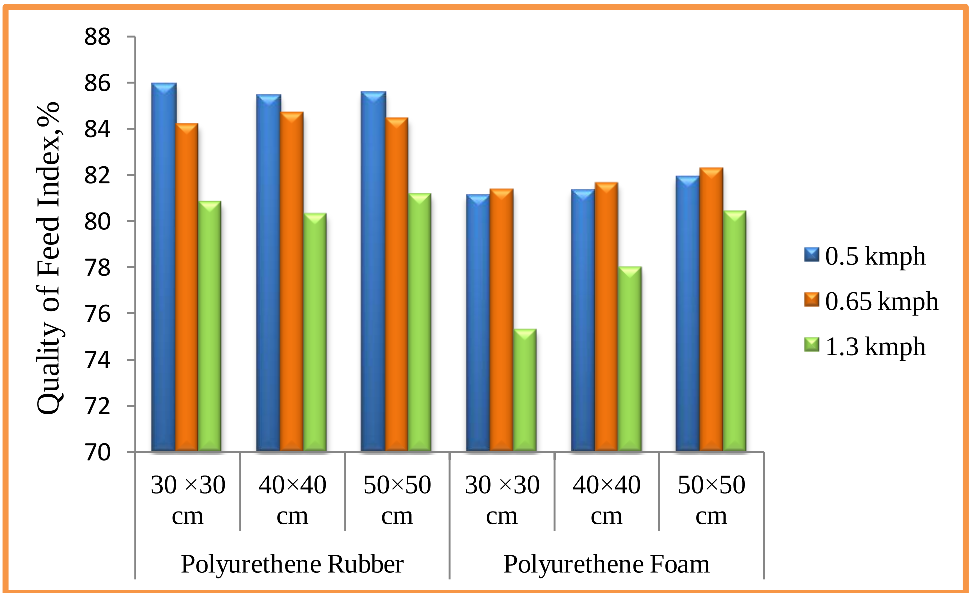

Fig 4.7 Quality feed index at selected levels

Table 4.10 ANOVA for quality feed index at different forward speed (N), type of rotor material (R) and check row spacing (S)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Factor R	1	142.4	142.4	120.7	0.00*
Factor N	2	194.1	97.0	82.3	0.00*
Int RX N	2	6.1	3.1	2.6	0.09
Factor S	2	12.6	6.3	5.4	0.01*
Int R X S	2	10.7	5.3	4.5	0.02*
Int N X S	4	11.2	2.8	2.4	0.07
Int A X B X C	4	8.5	2.1	1.8	0.15
Error	36	42.5	1.2		
Total	53	428.1			

*Note: * Significant at 5% level of significance*
R= rotor material, N= speed, S= Spacing

4.3.3 Effect of forward speed, type of rotor material and check row spacing on multiple index

The mean values of multiple index at different levels of variables under study viz., forward speed, type of rotor material, and check row spacing was determined. The multiple index was observed to vary in the range of 8.58-11.31 per cent, 8.20-13.06 per cent for polyurethane rubber and polyurethane foam made rotor, respectively (Table 4.11). The lowest multiple index value of 8.58 per cent and highest value of 11.31 per cent were observed for polyurethene foam type rotor. Multiple index was found to vary significantly with forward speed, type of rotor material, and check row spacing at 5 per cent level of significance (Table 4.12). It was observed that the multiple index decreased with increase in forward speed and increased as the check row spacing increased (Fig 4.8). This was due to difficulty in seed singulation at higher forward speed.

Table 4.11 Multiple index at forward speed, type of rotor material and check row spacing

Material	Spacing	Multiple Index (%)		
		0.5 kmh^{-1}	0.65 kmh^{-1}	1.3 kmh^{-1}
Polyurethene Rubber	30 ×30 cm	8.20	8.99	6.07
	40×40 cm	9.34	10.25	8.81
	50×50 cm	9.91	11.31	9.30
Polyurethene Foam	30 ×30 cm	12.34	11.51	8.82
	40×40 cm	12.67	11.82	8.68
	50×50 cm	13.06	11.79	8.58

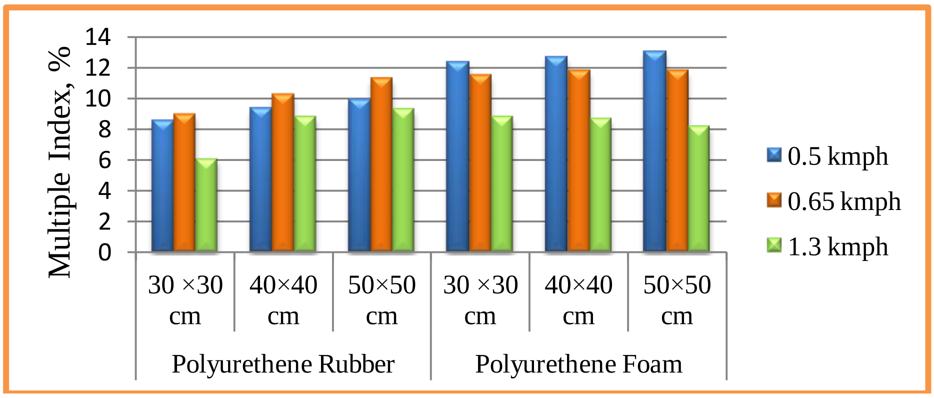

Fig 4.8 Multiple index at selected levels

Table 4.12 ANOVA for multiple index at selected levels

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Factor R	1	44.50	44.50	30.80	0.00*
Factor N	2	84.32	42.16	29.18	0.00*
Int RX N	2	19.55	9.78	6.77	0.00*
Factor S	2	14.04	7.02	4.86	0.01*
Int R X S	2	10.90	5.45	3.77	0.03*
Int N X S	4	1.01	0.25	0.18	0.95
Int A X B X C	4	4.53	1.13	0.78	0.54
Error	36	52.02	1.45		
Total	53	230.87			

*Note: * Significant at 5% level of significance*
R= rotor material, N= speed, S= Spacing

4.3.4 Effect of forward speed, type of rotor material and check row spacing on miss index

The observed values of miss index were in the range of 4.24-13.10 per cent, and 5.04-15.86 per cent for polyurethane rubber and polyurethane foam, respectively (Table 4.13). The lowest miss index value of 4.24 per cent was observed for polyurethane rubber type rotor at a forwarding speed of 0.65 kmh^{-1} for an input check row spacing of 50 x50 cm, while the highest miss index value of 15.86 per cent observed at a forward speed of 1.3 kmh^{-1} and 30 x 30 cm input spacing was observed for polyurethane foam made rotor. It was observed that miss index increased with increase of forward speed and decreased with increase in check row spacing (Fig 4.9). This may be attributed to the reason that at higher speed, the less sensing time was available to actuate stepper motor. From the statistical analysis of the data, miss index was found significantly influenced by forward speed, type of rotor material, and check row spacing as well as their interaction at 5% level of significance (Table 4.14).

Table 4.13 Missing Index at different forward speed, type of rotor material and check row spacing

Material	Spacing	Missing Index		
		0.5 kmh^{-1}	0.65 kmh^{-1}	1.3 kmh^{-1}
Polyurethene Rubber	30 ×30 cm	7.08	6.81	13.11
	40×40 cm	5.19	3.81	10.89
	50×50 cm	4.52	4.24	9.53
Polyurethene Foam	30 ×30 cm	6.53	7.12	15.86
	40×40 cm	6	6.51	13.32
	50×50 cm	5.04	5.91	11.02

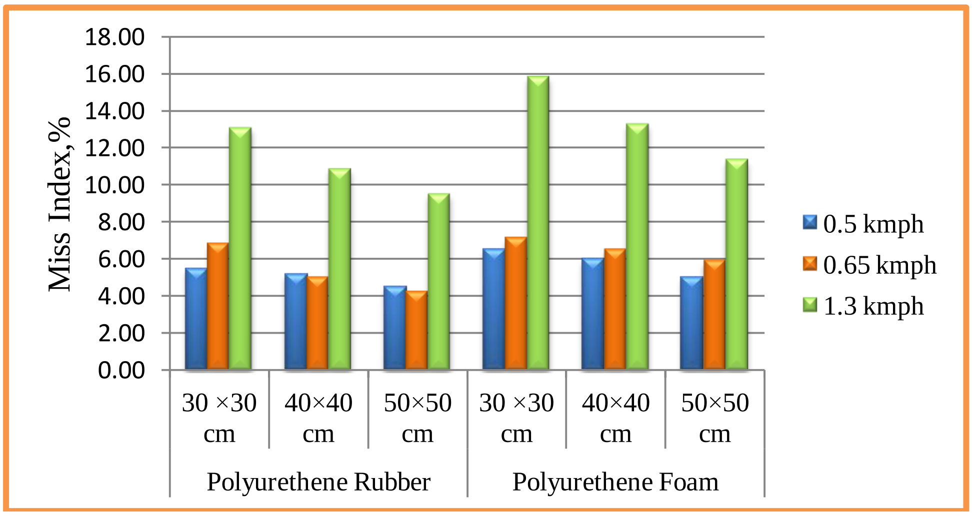

Fig 4.9 Effect of forward speed, type of rotor material and check row spacing on miss index

Table 4.14 ANOVA for missing Index at selected levels

Source of Variation	DF	Sum of Squares	Mean Squares	FCalculated	Signficance
Factor R	1	27.62	27.62	258.72	0.00*
Factor N	2	533.24	266.62	2,497.456	0.00*
Int RX N	2	5.98	2.99	28.00	0.00*
Factor S	2	51.04	25.52	239.07	0.00*
Int R X S	2	0.13	0.07	0.62	0.54
Int N X S	4	13.55	3.39	31.74	0.00*
Int A X B X C	4	2.30	0.58	5.39	0.002*
Error	36	3.84	0.11		
Total	53	637.71			

*Note: * Significant at 5% level of significance*
R= rotor material, N= speed, S= Spacing

4.3.5 Effect of forward speed, type of rotor material, and check row spacing on seed rate

The mean seed rate at different levels of selected variables was found in the range of 9.81- 36.76 kg ha^{-1}. It was observed that as the input seed spacing increased the seed rate decreased. The seed rate at different speeds was respectively observed in the range of 9.81-13.33 kg ha^{-1}, 15.55-19.86 kg ha^{-1} and 19.75- 31.86 kg ha^{-1} for respective input seed spacing of 30 ×30 cm, 40×40 cm and 50×50 cm for polyurethane rubber rotor. For polyurethane foam type rotor, the same was observed in the range of 18.81-35.02 kg ha^{-1}, 13.36-24.3 kg ha^{-1}, 10.82-16.87 kg ha^{-1} respectively at an input seed spacing of 30 ×30 cm, 40×40 cm and 50×50 cm (Table 4.15). It was observed that as the forward speed increased the seed rate decreased (Fig 4.10). This was because of the reason of higher miss index at higher speeds. Statistical analysis inferred that seed rate was affected by different levels of study variables and the effect was significant at 5 per cent level of significance (Table 4.16).

Table 4.15 Effect of forward speed, type of rotor material and check row spacing on seed rate

Material	Spacing	Seed Rate kg/ha		
		0.5 kmh^{-1}	0.65 kmh^{-1}	1.3 kmh^{-1}
Polyurethane Rubber	30 ×30 cm	31.86	30.42	19.75
	40×40 cm	19.86	20.25	15.55
	50×50 cm	13.33	12.25	9.81
Polyurethane Foam	30 ×30 cm	35.02	36.76	18.81
	40×40 cm	24.3	22.22	13.36
	50×50 cm	15.55	16.87	10.82

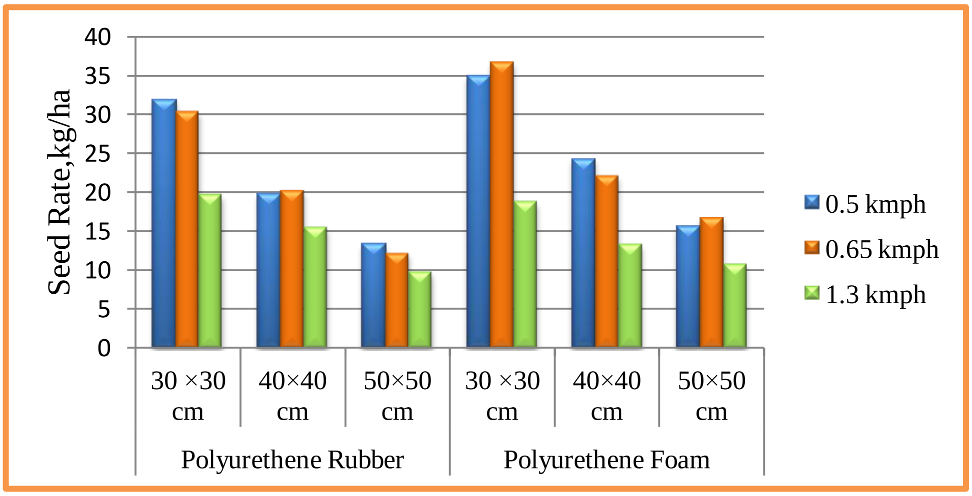

Fig 4.10 Variations in seed rate at selected levels

Table 4.16 ANOVA for seed rate at different forward speed (N), type of rotor material (R) and check row spacing (S)

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Factor R	1	70.97	70.97	95.30	0.00*
Factor N	2	875.80	437.90	588.04	0.00*
Int RX N	2	63.08	31.54	42.36	0.00*
Factor S	2	2,242.464	1,121.232	1,505.660	0.00*
Int R X S	2	5.40	2.70	3.63	0.04*
Int N X S	4	214.65	53.66	72.06	0.00*
Int A X B X C	4	20.65	5.16	6.93	0.00*
Error	36	26.81	0.75		
Total	53	3,519.825			

*Note: * Significant at 5% level of significance*
R= rotor material, N= speed, S= Spacing

4.4 Optimized values for sensor controlled seed metering mechanism of check row planting.

Based on the experimental results the following points could be summarised.

The seed metering plate was designed with a cone shaped groove of radius 5.25 mm based on measured lowest mean diameter. The slope of the seed transfer unit (seed tube) was decided based on lowest mean values of spherecity (0.83) and aspect ratio (0.82). To ensure the free flow of seeds in a hopper, the slope of the seed hopper should be higher than the angle of repose of seeds, so that 30^0 was used to decide the slope of the cone shaped groove on seed metering plate. Seeds that fell on the galvanized iron experienced minimum coefficient of friction therefore galvanized iron was used for the fabrication of seed hopper. The mean bulk density value of 863.64 kg/$m^3$was used to decide the volume of seed hopper.

The optimum design values of number pulse to the stepper motor for better singulation were 50, 60 and 70 for polyurethane rubber and 60, 70, and 80 at 0.5 kmh^{-1}, 0.65 kmh^{-1} and 1.3 kmh^{-1} respectively for both the seed metering rotor materials. The mean value of plant to plant spacing of 39.76 cm was found very close to the theoretical spacing of 40 cm at 0.65 kmph for polyurethane rubber seed metering plate. The highest quality of feed index 85.94% was observed at 0.65 kmph for polyurethane rubber rotor material at a check row spacing of 40×40 cm with lesser miss index of 3.81%.

4.5 Cost Estimation of designed seed metering mechanism

Table 4.17 Component wise cost of the sensor controlled seed metering unit

Sl.No.	Name of component	Material used for construction	Specification/ Dimensions	Quantity	Cost in Rs.
1.	Arduino-Uno	………………	Microcontroller-ATmega328 Operating Voltage -5V	1	300.00
2.	LIDAR Sensor	………………	Power-5 Vdc Nominal Range-40 m (131 ft) PWM interface Wavelength-905 nm	1	18000.00
3.	Stepper Motor	………………	Nema 23,Torque 10.1 kg-cm	1	800.00
4.	Stepper motor driver	………………	Operating voltage: 12-36 Vdc. Operating current: upto 3 A	1	3000.00
5	Jumper wire	………………	_Male to female	40	200.00
6	Seed plate	Corn Plastic	Inside dia 80 mm , outside dia 120 mm Thickness 30 mm	1	800.00
7	Seed metering rotor	Polyurethane Rubber	80 mm dia and 30 mm thickness	1	50.00
Total cost					23150.00

Total material cost= Rs 23150.00

Fabrication cost= Rs 2000.00

So, Total cost of the sensor controlled seed metering unit = Rs 25150.00

Unit cost of the research prototype was estimated as Rs.25150/- however, the manufacturing cost per unit may be reduced when it is fabricated in bulk.

Chapter 5

DISCUSSION

Seeding or the planting is one of the most important basic agricultural operations which decide plant density and crop production. Successful mechanization of planting and sowing is of utmost importance as yield depends on timely sowing and proper establishment of the crop. Delay in sowing results in loss of yield. The planting geometry varies with the type of crop and it influences subsequent intercultural operations and has significant impact on the crop yield. Check row planting is the method of planting in which row to row and plant to plant distance is equal. This planting pattern increases the yield since weeding can be done in both directions. Normally for sowing seed drill or planter is used. Planter is an advancement of seed drill in which plant to plant distance is maintained constant. The main constrain of existing planters in achieving check row pattern is slippage of ground wheel which varies the alignment of seeds as of previous rows. Farmers are following manual dibbling method to achieve the check row pattern. In view of the aforesaid facts and need, a sensor controlled seed metering mechanism for check row planting was designed and evaluated in laboratory conditions. The main aim of the study was to overcome problem in ground wheel slippage and have better precision with required spacing. The results needed to be justified based on laboratory evaluations, comparative analysis of developed system. Different rationales and reasoning regarding the obtained results are presented in this chapter.

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5.1 Variation in physical properties of seeds and its influence on design of seed metering unit

Design of sensor controlled seed metering system required study of crop and machine parameters and their relationship. The seed metering system should be imparted capability to accommodate different varieties and seed condition to place seed precisely at recommended spacing. To accommodate various varieties, two varieties were taken for the study, to encompass varying seed dimensions of green pea seeds. For the design of seed metering plate, the average major diameter (7.88 mm), minor diameter (5.25 mm) of two green pea varieties taken as 5.775 mm and 8.66 mm (10 per cent more than the maximum seed dimension). The physical properties evaluated lead to the selection of design value like material of hopper based on frictional property, angle of hopper based on angle of repose and depth of cylinder based on the average major diameter. The bulk density of seeds was used to design the hopper volume.

5.2 Optimization of number of pulse to stepper motor for seed singulation

The tolerance limit of LIDAR sensor was programmed to only 10 micro seconds (pulse width of 10 micro seconds = 1 cm of distance). Due this tolerance limit microcontroller was unable send programmed number of pulse to stepper motor at higher forward speeds. If only one pulse input was kept constant for all forward speeds, it resulted in higher missing and multiple indices. So required number of pulse to the stepper motor were optimized at different forward speeds for different material of seed metering to get correct singulation from all three outlets. The optimized values of pulse input at different forward speeds were found to give higher quality of feed index thereby reducing missing and multiples.

5.3 Design parameters and performances indices for precision planting

The design parameters that affected the performance of a planter were identified as forward speed of operation, material of seed metering rotor, and check row spacing. The levels of variables for the laboratory investigation were forward speed of operation (0.5,0.65 and 1.3 km h^{-1}), material of seed metering rotor (polyurethane rubber and polyurethane foam) and check row spacing *viz.,* 30 ×30 cm, 40 ×40 cm and 50 ×50 cm. The performance was studied with respect to quality feed index, mean hill spacing, seed rate, miss index and multiple index.

It was observed that the quality of feed index decreased with increase in forward speed. This may be due to the reason that at higher speed the response time of the distance sensor may be decreasing, due to this degree of rotation of stepper motor was less than input pulse. At higher speed, occurrence of more missing might have caused decrease of quality feed index, While at lower speeds the stepper motor rotates at a given amount of input pulse which gave higher quality of feed index and lesser missing. The mean spacing was closer to the input spacing for polyurethane rubber compared to polyurethane foam it may reason that the frictional properties required to singulate seeds may be optimum for polyurethane rubber. Mean spacing was increased with increase in forward speed may be due to lesser response time. It was observed that the multiple index was higher for the polyurethane foam may due to lower coefficient of friction between seed and rotor and also it was observed that seed rate was decreased as the spacing increased because area was increasing for the same number of seeds and seed rate was decreased at higher forward speeds due higher seeds missing.

For overcoming the effect of ground wheel slippage and achieving better precision, a sensor controlled metering mechanism was incorporated in the developed system. The system was based upon the concept of distance based actuation of seed metering rotor. This was achieved through sensing distance between reflective surface and sensor thereby actuation of stepper motor to actuate the metering plate to get required plant to plant spacing. The system was tested in the soil bin and the results of precision analysis supported the advancement of technology and its usefulness for the end users. The observed results for, spacing, quality of feed index, miss and multiple indices of sensor controlled seed metering mechanism were found better

Thus the designed planter can help in overcoming the problems faced in existing planters and benefits for check row planting.

Chapter 6

SUMMARY AND CONCLUSIONS

Check row planting is method of planting in which row to row distance and plant to plant distance is maintained constant so that seeds are aligned in straight as well as transverse direction. Check row planting enables weeding in both directions, thus significantly reducing the weed population. This method allows sufficient space all around the crop which helps in proper aeration and sunlight reaches up to the bottom of crop.

In India Farmers are practicing manual dibbling methods viz., by using tagged rope, marking by datari, ridger and bund former which is very laborious and time consuming. The existing planters are unable maintain check row due to ground wheel slippage therefore a sensor controlled seed metering mechanism for check row planting was designed and evaluated for green peas in laboratory conditions. Initially the physical properties of green peas were determined to design the seed metering plate. Different electronic components were selected and were assembled with the seed metering unit to develop a sensor controlled seed metering mechanism. An experiment was conducted to optimize number of input pulse to stepper motor at different forward speeds for correct seed singulation. Based on these optimized input pulse the parameters viz., quality of feed index, multiple index, missing index, seed rate and mean spacing were evaluated for three forward speeds (0.5, 0.65 and 1.3 kmph) , two material of seed metering rotor (polyurethane rubber and polyurethane foam) and three check row spacing (30×30 cm, 40×40 cm and 50×50 cm).

Based on the analysis of the results, the following conclusions could be drawn.

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i. The lowest mean diameter of 5.25 mm was used to decide the radius of the cone shaped grove on the seed metering plate.

ii. The lowest mean values of spherecity (0.83) and aspect ratio (0.82) were used to deside the slope of the seed transfer unit (seed tube).

iii. To ensure the free flow of seeds in a hopper, the slope of the seed hopper should be higher than the angle of repose of seeds, so that 30^0 was used to decide the slope of the cone shaped groove on seed metering plate. The mean bulk density value of 863.64 kg/m^{3}was used to decide the volume of seed hopper.

iv. The optimum design values of number pulse to the stepper motor for better singulation were 50, 60 and 70 for polyurethane rubber and 60,70, and 80 at 0.5 kmh^{-1}, 0.65 kmh^{-1} and 1.3 kmh^{-1} respectively for both the seed metering rotor materials.

v. The developed system was evaluated at three check row planting pattern viz., 30 ×30 cm,40 ×40 cm and 50 ×50 cm at 0.5,0.65 and 1.3 kmh^{-1} for two types of seed metering rotor.

vi. The mean value of plant to plant spacing of 39.76 cm was found very close to the theoretical spacing of 40 cm at 0.65 kmph for polyurethane rubber seed metering plate and the highest quality of feed index 85.94% was observed at 0.65 kmph for polyurethane rubber rotor material at a check row spacing of 40×40 cm with lesser miss index of 3.81%.

vii. The unit cost of the research prototype was estimated as Rs.25150/-

Design and development of sensor controlled mechanism of seed metering for check row planting

Abstract

Planting is one of the most important basic farm operations in agriculture as it decides the production and productivity of crops. Precision seeding can save seeds and facilitate subsequent mechanical field operations. Broadcasting, drilling, planting and check row planting are the different methods of seeding practiced in India. The check row planting is the method of planting in which row to row and plant to plant spacing is equal. This method of planting allows bidirectional weeding; better aeration and sunlight to plants increased the crop yield. Even though in existing planters row-to-row and seed to seed distance is maintained, seeds are not aligned in transverse direction as previous rows because of skidding (10 to 30%) of ground wheel, which vitiates indexing efforts for alignment. To overcome these limitations the study was conducted to develop a sensor controlled seed metering mechanism for check row planting. The horizontal plate seed metering unit consisted of stationary seed metering plate and seed metering rotor was taken for the study. The seed properties were determined to design the seed metering plate and rotor. The seed from the seed box fed to the seed metering plate and pushed the seed to seed tube by rotation of seed metering rotor. The speed of the seed metering rotor, frictional force between the surfaces of the stationary seed metering plate and seed metering rotor controlled the seed metering. The seed metering rotor was driven by the stepper motor. The angle of rotation of stepper motor was optimized to obtain better singulation at 0.5, 0.65 and 1.3 kmph forward speeds and two types of rotor material i.e polyurethane rubber and polyurethane foam. The ground wheel of seed drill was replaced with LIDAR proximity sensor and mounted on seed metering unit was used to sense the distance from a reflector. The LIDAR sensor sent input to the microcontroller at the predetermined spacing, which was programmed in the microcontroller. The stepper motor was actuated by the microcontroller and drove seed metering rotor as per the signal received from LIDAR. The optimized values of number input pulse were 50 ,60,70 pulse are required for polyurethane rubber at 0.5,0,65 and 1.3 kmph forward speeds respectively while 60,70,80 pulse are required for polyurethane foam at 0.5,0.65 and 1.3 kmph for effective seed singulation. These optimized values of angle rotation were used to evaluate the performance parameters viz., quality of feed index, miss index, multiple index, and mean spacing at three check row spacing (30×30 cm, 40×40 cm and 50×50 cm) for two rotor materials (polyurethane rubber and polyurethane foam) and at three forward speeds 0.5, 0.65 and 1.3 kmph. The mean value of plant to plant spacing of 39.76 cm was found very close to the theoretical spacing of 40 cm at 0.65 kmph for polyurethane rubber seed metering plate. The highest quality of feed index 85.94% was observed at 0.65 kmph for polyurethane rubber rotor material at a check row spacing of 40×40 cm. The sensor controlled seed metering mechanism was performed better with polyurethane rubber as rotor material at lower speeds irrespective of spacing.

चेक रौ प्लांटिंग के लिए सेंसर नियंत्रित बीज मीटरिंग तंत्र का डिज़ाइन और विकास

सार

प्लांटिंग कृषि में सबसे महत्वपूर्ण मूल कृषि कार्यों में से एक है क्योंकि यह फसलों के उत्पादन और उत्पादकता का निर्णय करता है। शुद्धता बोने बीज को बचा सकते हैं और बाद के मैकेनिकल फील्ड ऑपरेशन को सुविधाजनक बना सकते हैं। प्रसारण, ड्रिलिंग, प्लांटिंग और चेक रौ प्लांटिंग भारत में प्रचलित बीजों के विभिन्न तरीकों हैं। चेक रौ प्लांटिंग बोने की विधि है जिसमें पंक्ति और पंक्ति, पौधा और पौधा के बीच का अंतर समान होता है। प्लांटिंग के इस विधि घास का निष्कासन द्विदिश में अनुमति देता है; पौधों को बेहतर वातन और सूर्य के प्रकाश ने फसल की उत्पादन में वृद्धि की। भले ही मौजूदा प्लांटर्स में पंक्ति से पंक्ति और बीज से बीज की दूरी बनाए रखा हो, बीज ग्राउंड व्हील के स्किडिंग (10 से 30%) की वजह से बीजों को पिछले पंक्तियों के रूप में अनुक्रमिक दिशा में संरेखित नहीं किया गया है,जो संरेखण के लिए अनुक्रमण प्रयासों को बिगड़ता है। इन सीमाओं पर काबू पाने के लिए एक सेंसर नियंत्रित बीज मीटरिंग तंत्र विकसित करने के लिए अध्ययन किया गया था। क्षैतिज प्लेट बीज मीटरिंग इकाई में स्थिर बीज मीटिंग प्लेट और बीज मीटरिंग रोटर शामिल थे जो अध्ययन के लिए लिया गया था। बीज गुणों को बीज मीटरिंग प्लेट और रोटर डिजाइन करने के लिए निर्धारित किया गया था। बीज के बीज से बीज बीज पैमाइश प्लेट में खिलाया और बीज मीटरिंग रोटर के रोटेशन द्वारा बीज को बीज धकेल दिया। बीज मीटरिंग रोटर की गति, स्थिर बीज मीटरिंग प्लेट और बीज मीटरिंग रोटर की सतहों के बीच घर्षण बल ने बीज मीटरिंग को नियंत्रित किया। बीज मीटरिंग रोटर स्टेपर मोटर द्वारा संचालित किया गया था। स्टेपर मोटर के रोटेशन के कोण को 0.5, 0.65 और 1.3 किमी प्रति फ़ॉरवर्ड स्पीड और दो प्रकार के रोटर मटेरियल में पोलिउरेथेन रबर और पॉलीयूरेथेन फोम में बेहतर सिंगुलेशन प्राप्त करने के लिए अनुकूलित किया गया था। बीज ड्रिल का ग्राउंड व्हील LIDAR निकटता संवेदक के साथ बदल दिया गया था और बीज मीटरिंग इकाई पर घुड़सवार एक परावर्तक से दूरी को समझने के लिए इस्तेमाल किया गया था। LIDAR संवेदक ने पूर्वनिर्धारित रिक्ति पर माइक्रोकंट्रोलर को इनपुट भेजा, जो कि माइक्रोकंट्रोलर में प्रोग्राम किया गया था। स्टेपर मोटर को माइक्रोकंट्रोलर द्वारा संचालित किया गया था और लीडर से प्राप्त संकेत के अनुसार बीज मीटरिंग रोटर चलाया गया था। संख्या इनपुट पल्स के अनुकूलित मूल्य 50, 60, 70 पल्स पॉलीयूरेथेन रबर के लिए क्रमशः 0.5,0,65 और 1.3 किमी प्रति सेकंड गति के लिए आवश्यक होते हैं जबकि 0.50.65 और 1.3 किमी प्रति घंटे के लिए पॉलीयूरेथेन फोम के लिए 60,70,80 पल्स की आवश्यकता होती है। प्रभावी बीज एकाग्रता के लिए कोण रोटेशन के इन अनुकूलित मूल्यों का उपयोग प्रदर्शन मापदंडों, फीड इंडेक्स की गुणवत्ता, मिस इंडेक्स, एकाधिक इंडेक्स, और तीन चेक पंक्ति रिक्ति (30 × 30 सेमी, 40 × 40 सेमी और 50 × 50 सेमी) दो रोटर सामग्रियों (पॉलीयूरेथेन रबर और पॉलीयूरेथेन फोम) के लिए और तीन अग्रेषण की गति 0.5, 0.65 और 1.3 किमी प्रति है। 39.76 सेंटीमीटर की रिक्ति लगाने के लिए पौधे का मतलब मूल्य पॉलीयूरेथन रबड़ बीड पैमाइश प्लेट के लिए 40 सेंटीमीटर की सैद्धांतिक रिक्ति के करीब 0.65 किमी प्रति मील के करीब पाया गया। फ़ीड सूचकांक 85.94% की उच्चतम गुणवत्ता 40.440 सेमी की एक चेक पंक्ति रिक्ति पर पॉलिरुएथेन रबर रोटर सामग्री के लिए 0.65 किमी प्रति घंटे में मनाई गई थी। संवेदक नियंत्रित बीज मीटरिंग तंत्र बेहतर प्रदर्शन किया गया था, जहां रियर सामग्री कम दूरी पर रियररेट के रूप में रिक्ति के बावजूद बेहतर होती है।

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Appendix A

Program to run the controlling unit:

```
#include <Stepper.h>

const int stepsPerRevolution =50;

Stepper myStepper(stepsPerRevolution, 8, 9, 10, 11);

unsigned long pulseWidth;

void setup()

{ myStepper.setSpeed(400);

  Serial.begin(115200);

  pinMode(2, OUTPUT);

  digitalWrite(2, LOW);

  pinMode(3, INPUT);

 }

void loop()

{

 pulseWidth = pulseIn(3, HIGH);

 Serial.println(pulseWidth);

if(pulseWidth >= 17900 && pulseWidth<= 17910
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 17600 && pulseWidth<= 17610
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 17300 && pulseWidth<= 17310
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 17000 && pulseWidth<= 17010
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 16700 && pulseWidth<= 16710
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 16400 && pulseWidth<= 16410
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}
```

```
if(pulseWidth >= 16100 && pulseWidth<= 16110
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 15800 && pulseWidth<= 15810
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 15500 && pulseWidth<= 15510
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 15200 && pulseWidth<= 15210
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 14900 && pulseWidth<= 14910
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 14600 && pulseWidth<= 14610
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 14300 && pulseWidth<= 14310
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 14000 && pulseWidth<= 14010
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 11370 && pulseWidth<= 13710
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 13400 && pulseWidth<= 13410
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 13100 && pulseWidth<= 13110
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 12800 && pulseWidth<= 12810
){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

if(pulseWidth >= 12500 && pulseWidth<=
12510){myStepper.step(stepsPerRevolution);}else {myStepper.step(0);}

}
```

Appendix B

Specifications of LIDAR sensor:

Physical

Specification	Measurement
Size (LxWxH)	20 × 48 × 40 mm (0.8 × 1.9 × 1.6 in.)
Weight	22 g (0.78 oz.)
Operating temperature	-20 to 60°C (-4 to 140°F)

Electrical

Specification	Measurement
Power	5 Vdc Nominal 4.5 Vdc min., 5.5 Vdc max.
Current consumption	105 mA idle 135 mA continuous operation

Performance

Specification	Measurement
Range (70% reflective target)	40 m (131 ft)
Update rate (70% Reflective Target)	270 Hz typical 650 Hz fast mode >1000 Hz short range o
Resolution	+/- 1 cm (0.4 in.)
Accuracy < 5 m	±2.5 cm (1 in.) typical
Accuracy > 5 m	±10 cm (3.9 in.) typical Mean ±1% of distance maximum Ripple ±1% of distance maximum
Repetition rate	~50 Hz default 500 Hz max

Laser

Specification	Measurement
Wavelength	905 nm (nominal)
Total laser power(peak)	1.3 W
Mode of operation	Pulsed (256 pulse max. pulse train)
Pulse width	0.5 µs (50% duty Cycle)
Pulse train repetition frequency	10-20 KHz nominal
Energy per pulse	<280 nJ
Beam diameter at laser aperture	12 × 2 mm (0.47 × 0.08 in.)
Divergence	8 mRadian

Interface

Specification	Measurement
User interface	l2C interface PWM interface External trigger
I2C interface	Fast-mode (400 kbit/s) Default 7-bit address 0x62 Internal register access & control
PWM interface	External trigger input PWM output proportional to distance at 10 µs/cm