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Development and Performance Evaluation of Microcontroller Operated Planter

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ABSTRACT

Sowing is one of the important operations in crop production that involves factors like correct seed rate, appropriate depth of placement ad required seed space for maximum production. Ground wheel-driven conventional metering mechanism results in improper placement of seeds because of skidding and vibration of the ground wheel. To overcome this problem a microcontroller-based seed metering unit was developed and retrofitted to a planter. The microcontroller-operated planter was evaluated over ground wheel-driven planter for Maize seed. During the field trails it was observed that the average missing index, multiple index, and quality feed index of microcontroller operated planter was 6.6%, 10%, and 83.4% respectively. The average missing index, multiple index, multiple index and quality feed index of ground wheel-driven planter was 20.3%, 23.3%, and 56.4% respectively. It was also observed that sowing with a microcontroller-operated planter, there was a net saving of 20% of cost over ground wheel-driven planter.

Keywords: *Microcontroller, Planter, Missing index, Multiple index, Pulse width modulation and Quality feed index*

INTRODUCTION

Sowing is one of the critical operations in crop cultivation. The primary objective of any planting operation is to establish an optimum plant population and plant spacing. Because of non-uniform distribution of seeds in the field, results in a reduction of crop yield and production. Uniform seed distribution and performance of planter/seed drill depends on type of seed metering mechanism, speed, depth, soil covering and compaction attachments. Due to the agronomical requirements of different crops, there is always some scope for improvement in seed metering unit to meter the precise number of seeds. The existing planter/seed drill consists of a ground wheel, chain-sprocket transmission, and seed metering unit. Major factors that affect the precise placement of seeds are slippage between the planter's ground wheel and field, skidding of ground wheel and vibrations of mechanical transmission. Precision sowing of crops requires higher efficiency of planters/seed drill. The maximum yield in cultivated land significantly occurs at the optimal seeding rates [1]. Studies have shown that the uniform seed rate over the field decreases yield loss, competition between the plants, and the production cost of the crop [3]. This can be achieved by precision sowing machinery [4]. In the existing planters, the non- uniformity is due to ground wheel slippage (which causes un drop of seed variation in the range of 15-20% [11]). In present days, electronic controls are widely used in agriculture fields to make the machines more efficient, compact and light. To overcome the problems with existing ground wheel driven planters, microcontroller-operated planter was developed and its performance was evaluated against ground wheel-driven planter.

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MATERIALS AND METHODS

The microcontroller operated planter was developed at AICRP on FIM Scheme, and its performance was evaluated with maize seed at Agriculture Research Institute, Hyderabad. For this study an existing ground wheel-driven planter with an inclined plate seed metering mechanism was selected and the ground wheel of the selected planter is replaced with a microcontroller-based power transmission system.

Physical properties of maize seeds

Seed flow through a planter is dependent on the size and angle of repose [5]. Therefore, the physical properties of Maize seeds which affect the seed flow were measured to ascertain the suitability of the planter for sowing Maize seeds.

Size of Maize seed

The term "seed size" refers to the equivalent diameter of the seed. The physical size of seeds aids in the selection of cell length and depth of seed metering plate. Maize seeds were selected from commonly sown varieties of Maize (DHM-117 and DHM-121) and their three principal dimensions; Length (L), breadth (W) and thickness (T) were determined using a digital Vernier caliper (least count of 0.1mm) (Fig 1). The measurements were replicated five times. The Geometric mean diameter (Dg) values were found using the following formula [7].

$Dg = (LWT)^{1/3}$

Fig 1. Measurement of size by using Vernier caliper

Angle of repose

The angle of repose determines the flowability of seeds. The angle of repose was determined by placing the seeds in a conical container (Fig. 2). To determine this angle, seeds were placed in a conical container. The container, featuring a bottom opening, was gradually opened to allow the seeds to fall from a height of 300 mm, forming a heap. The height of the heap formed on a circular disk with a diameter of 200 mm was then recorded. This process was repeated five times, and the average values were calculated for analysis. The following equation was used to calculate the angle of repose of maize seeds [5].

$$\theta = tan^{-1}\frac{h}{r}$$

Where,

θ = Angle of repose,

h = Heap's height, mm and r = Heap's radius, mm.

Fig.2. Measurement of angle of repose

Development of microcontroller-operated seed metering unit

Based on the physical properties of the Maize seeds, a ground wheel-driven planter with a 3-row inclined plate seed metering mechanism was chosen for modification. The original ground wheel of this planter was replaced with a microcontroller-driven power transmission system.

Power for the microcontroller was sourced from a 12V tractor battery. The developed microcontroller-operated planter comprises a converter to adjust the voltage from 12V to 5V, necessary for powering the DC Tacho Generator responsible for sensing the tractor's forward motion. A Micro Controller (Arduino-based microcontroller board) (refer to Fig 5) automatically converts the RPM data into PWM data. A Pulse Width Modulator regulates the RPM supplied to the DC Motor of the metering unit. A Relay Driver unit controls the motor's activation based on input signals from the microcontroller. A Geared DC motor (12V, 250W) converts electrical energy into mechanical energy, coupled with a gearbox to augment torque (refer to Fig 3).

The choice of DC motor was made based on the torque requirements of the planter's seed metering shaft. Through laboratory testing using a torque sensor, the average torque demand for the 3-row planter was determined to be 10 N-m. Consequently, a geared DC motor operating at 147 RPM with 16 N-m torque and 250W power output was selected for the project.

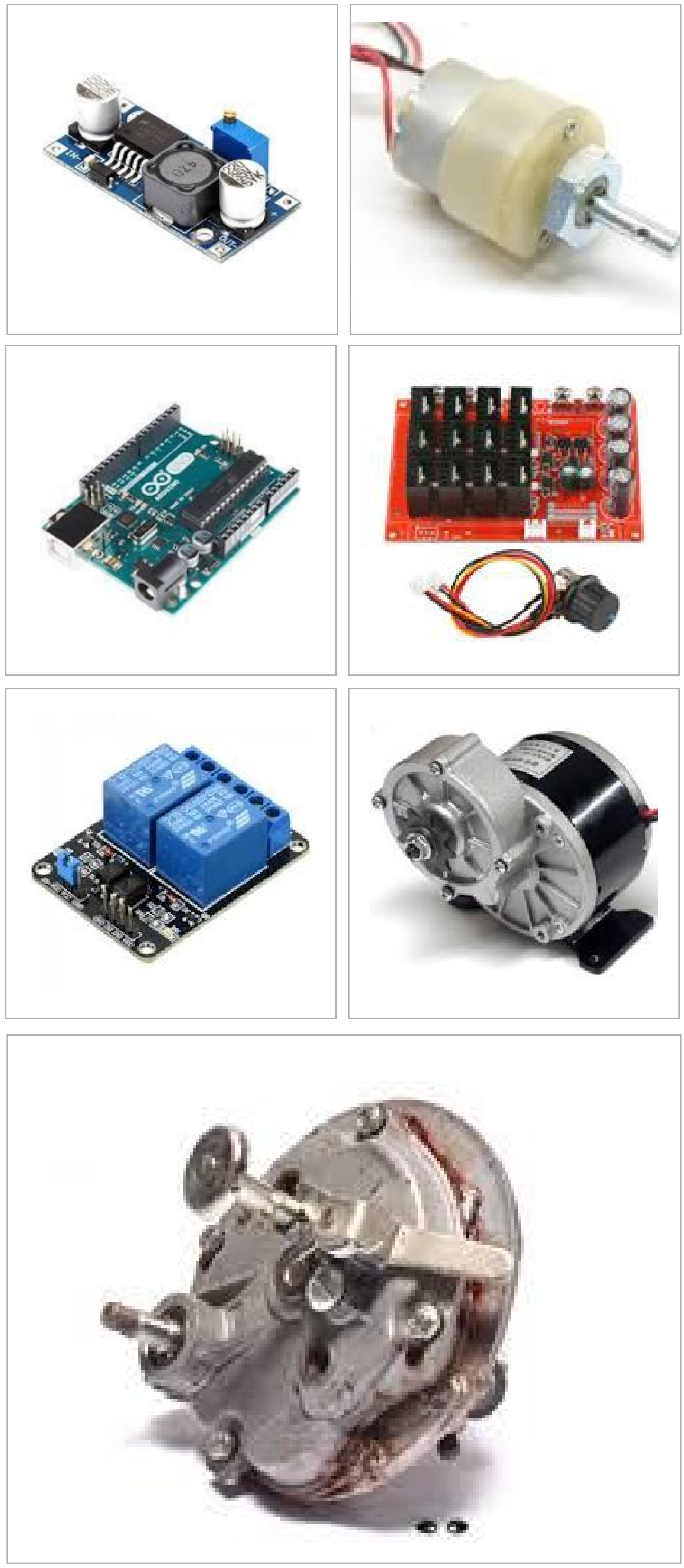

Fig.3. Components of Micro controller-based metering unit

Working of Microcontroller operated electronic metering system

A wheel RPM sensor (DC Tacho Generator) was installed on the front wheel of the tractor. This sensor detects the revolutions per minute (rpm) of the front wheel and transmits the signal to the microcontroller (refer to Fig 7). Upon receiving the signal from the tractor's front wheel, the microcontroller activates a relay driver via a PWM motor speed controller using PWM signal. The strength of the signal is adjusted using a potentiometer (refer to Fig. 6), which is connected to the motor controller and utilized to maintain the desired rpm of the geared DC motor. The power generated by the geared DC motor is then transferred to the seed metering shaft through a chain drive.

The block diagram of the microcontroller-operated planter is depicted in Fig 4, while the specifications of the developed microcontroller-operated planter are detailed in Table 1.

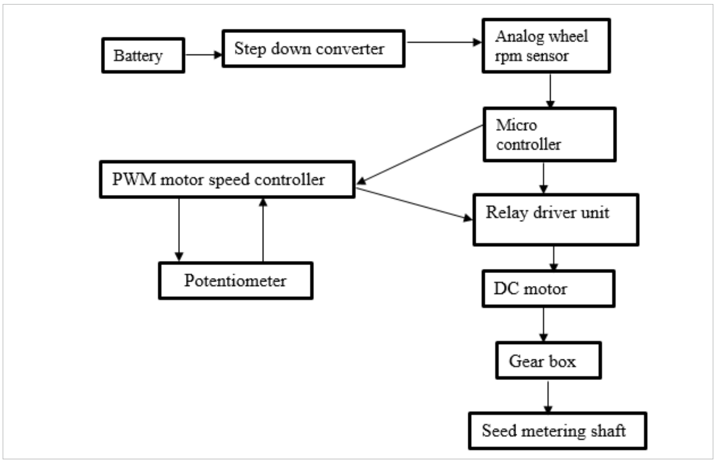

Fig.4. Block diagram of micro controller operated planter

Table 1: Specifications of developed microcontroller operated planter

S. No	Component	Details
1.	Power source	Tractor battery (12V)
2.	Overall dimensions (L x W x H), mm	2300 x 750 x 1100
3.	Number of rows	3
4.	Overall dimensions of seed hopper (L x W x H), mm	2080 x 380 x 240
5.	Seed metering mechanism	Inclined plate
6.	Furrow opener	Shovel type
7.	Microcontroller	ATMEGA328-PU
8.	Geared D C motor	24v, 250 watts

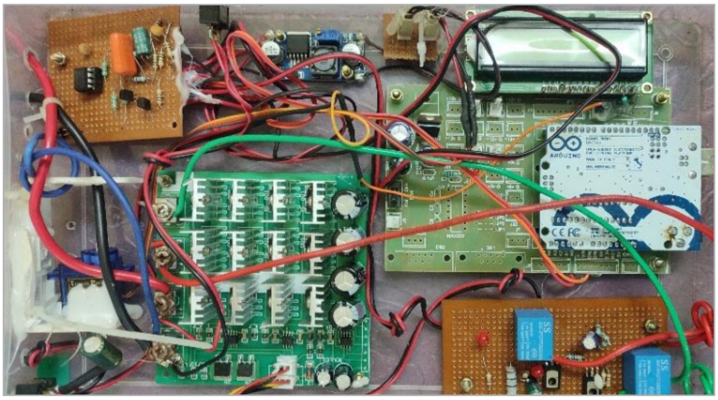

Fig.5. Microcontroller unit

Fig.7. Wheel RPM sensor attachment to tractor front wheel

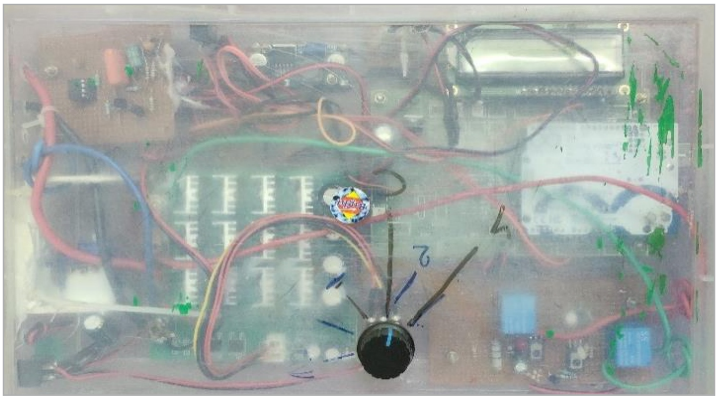

Fig.6. Potentiometer

Fig.8. Microcontroller unit attachment to planter

Fig.9. Developed Microcontroller Operated Planter

Experimental Design

To evaluate the performance of the developed microcontroller operated planter (Fig.9), three levels of forward speed (2, 2.5 and 3 km h^{-1}) were randomized in a one-way ANOVA design to carry out the field experiment (Table 2.). The best performing speed in terms of missing index, multiple index and quality feed index was evaluated against the ground wheel driven planter.

Table 2: Levels of experimental independent variables of one-way ANOVA design

Independent variables	Levels	Dependent variables
Forward speed, km h^{-1}	3	1. Missing index 2. Multiple index 3. Quality feed index 4. Effective field capacity

Measurement of performance parameters

The performance of the planters was evaluated in terms of seed spacing, missing index, multiple index, quality feed index, field capacity.

Missing Index

It is the total number of observations with spacings more than 1.5 times the theoretical spacing. It is due to the failure of the seed picking system or, due to lack of positive release of the seeds (Inderpal *et.al* 2020)

$$MI = \frac{n1}{N} \times 100$$

Where,
MI=Missing index,
n_1=The total number of observations with spacing more than 1.5 times of the theoretical spacing
N = Total observations.

Multiple Index

Multiple index is the total number of spacings, which are less than 0.5 times theoretical spacing. It is the number of cases, where the plate picks more than one seed per groove which results in wastage of the costly seeds and input of the operations of planting [6]

$$M_p I = \frac{n2}{N} \times 100$$

Where,
M_pI=Multiple index, %
n_2= Total number of observations with spacing, which are less than 0.5 times of
the theoretical spacing
N=Total observations

Quality of Feed Index

It is the number of observations, which are 0.5 to 1.5 times the theoretical spacing. Higher is the quality of feed index, better is the performance of the metering mechanism [6]

$$QI = \frac{n3}{N} \times 100$$

Where,
QI = Quality of feed Index, %
n_3 = Number of observations, which are 0.5 to 1.5 times of the theoretical spacing
N = Total observations

Effective Field Capacity

Effective field capacity of planter was measured by taking both productive and nonproductive time into consideration and area covered. The effective field capacities and field efficiencies were calculated as

$$\text{Effective field capacity (ha/h)} = \frac{Plot\ area(ha)}{Time\ required\ to\ cover\ the\ plot(h)}$$

Cost analysis

The cost of operation of the planter per hectare was determined considering the fixed cost and variable cost planter.

RESULTS AND DISCUSSION

The developed microcontroller operated planter was evaluated at Agriculture Research Institute, Rajendranagar, Hyderabad (Fig 10). The Geometric mean diameter (Dg) of DHM-117 andDHM-121 varieties were 6.36 mm and 6.23mmand the angle of repose were 22.47° and 24.52° respectively. Sowing was done with DHM 117 variety using both the developed microcontroller operated planter and ground wheel driven planter in an area of 1500 m^2 at a spacing of 600 x 200 mm. The developed microcontroller operated planter was operated at three forward speeds of 2 km h^{-1}, 2.5 km h^{-1} and 3 km h^{-1}. It was observed that the developed planter is performing better in terms of missing index, multiple index and quality feed index at 2 km h^{-1} speed (Table 4). Therefore, the microcontroller operated planter and ground wheel driven planter were evaluated at 2 km h^{-1} speed in the field condition.

Fig.10. Field evaluation of developed planter

The results of microcontroller operated planter against ground wheel driven planter were given in Table.3 and analyzed using T test and the performance of microcontroller operated planter at different forward speeds were analyzed by using ANOVA design expert software.

It was observed that the effective field capacity and field efficiency of microcontroller operated planter were found to be 0.35 ha h^{-1} and 77.7% while for the mechanical (ground wheel driven) planter was observed to be 0.31 ha h^{-1} and 68.8% respectively. The statistical analysis infers that the effect of forward speed significantly influenced effective field capacity at 1% level of significance (Table 5). It was observed that increase in forward speed increased the effective field capacity (Fig11).

Table3: Field evaluation of microcontroller operated planter and ground wheel driven planter

Sl. No	Parameters	Microcontroller operated planter	Ground wheel driven planter
1	Effective field capacity, ha h^{-1}	0.35	0.31
2	Field efficiency, %	77.70	68.80
3	Fuel consumption, l h^{-1}	3.5	3.8
4	Forward speed, km h^{-1}	2	2
5	Missing index, %	6.60	20.30
6	Multiple index, %	10	23.30
7	Quality feed index, %	83.4	56.4
8	Average seed spacing, mm	214	246

Table 4: Mean Performance table of micro controller operated planter

Sl. No	Parameters	Forward Speed (km h^{-1})		
		2.0	2.5	3.0
1	Effective field capacity, hah^{-1}	0.35	0.36	0.42
2	Missing index, %	6.63	7.63	14.37
3	Multiple index, %	10.33	14.33	25.00
4	Quality feed index, %	83.03	78.03	60.63

Table 5: Analysis of variance of effective field capacity for different forward speeds

Source	Sum of Squares	df	Mean Square	F Value	p-value	Prob > F
Model	0.008022	2	0.004011	120.3333	< 0.0001	Significant
A-speed	0.008022	2	0.004011	120.3333	< 0.0001	
Pure Error	0.0002	6	3.33E-05			
Cor Total	0.008222	8				

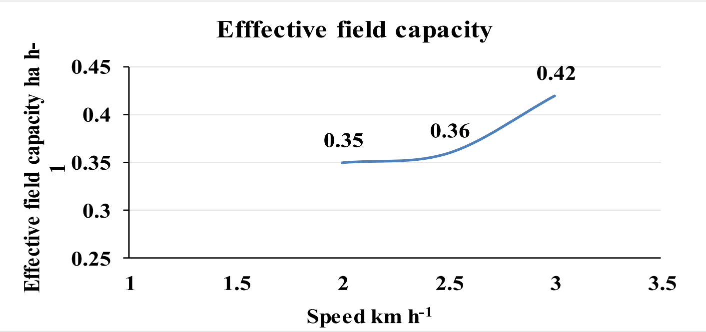

Fig.11. Effect of forward speed(km h^{-1}) on effective field capacity(ha h^{-1})

Missing index

The average missing index of microcontroller operated and mechanical planter was observed as 6.6% and 20.3% respectively, The statistical analysis infers that the effect of forward speed significantly influenced missing index at 1% level of significance (Table 6). It was observed that increase in forward speed increased missing index (Fig12). It may be due to at higher speed, the cell exposure time was less for filling of seed in cell from the hopper. Similar results were reported by [10].

Table 6. Analysis of variance of Missing index for different forward speeds

Source	Sum of Squares	df	Mean Square	F Value	p-value	Prob > F
Model	106.1422	2	53.07111	3184.267	< 0.0001	Significant
A-speed	106.1422	2	53.07111	3184.267	< 0.0001	
Pure Error	0.1	6	0.016667			
Cor Total	106.2422	8				

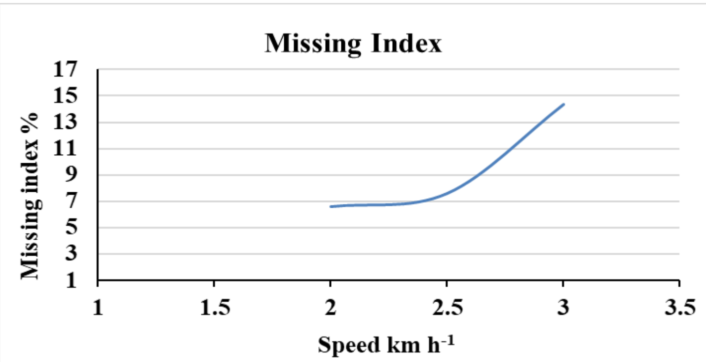

Fig.12. Effect of forward speed(kmh^{-1}) on Missing index (%)

Multiple index:

The average multiple index of microcontroller operated and mechanical planters were found to be 10% and23.3% respectively. The statistical analysis infers that the effect of forward speed significantly influenced multiple index at 1% level of significance (Table 7). It was observed that increase in forward speed increased multiple index (Fig13.) This may be due to a higher forward speed, the exposure time was low for removal of extra seed from the cell. Similar results were reported by [8].

Table 7. Analysis of variance of Multiple index for different forward speeds

Source	Sum of Squares	df	Mean Square	F Value	p-value	Prob > F
Model	344.8889	2	172.4444	310.4	< 0.0001	significant
A-speed	344.8889	2	172.4444	310.4	< 0.0001	
Pure Error	3.333333	6	0.555556			
Cor Total	348.2222	8				

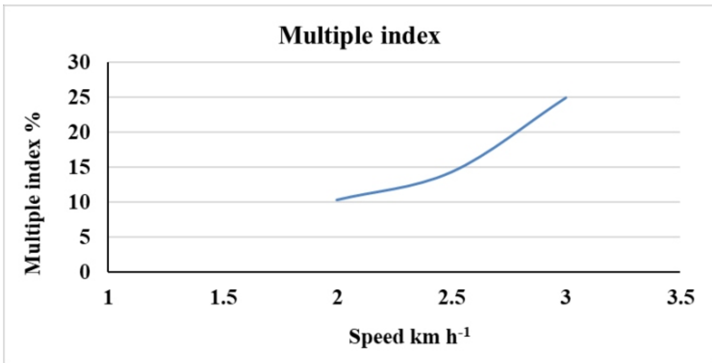

Fig.13. Effect of forward speed(kmh^{-1}) on Multiple index (%)

Quality feed index

The average quality feed index for microcontroller-operated planters stood at 83.34%, whereas for mechanical planters, it was 56.4%. Statistical analysis reveals that the forward speed had a significant impact on the quality feed index at a 1% level of significance (refer to Table 8). Notably, an increase in forward speed was associated with a decrease in the quality feed index (see Fig14). This trend may be attributed to the limited time available for seeds to occupy the metering cell at higher speeds, a phenomenon supported by similar findings from prior research [11].

Furthermore, the average seed spacing was measured at 214 mm and 246 mm for microcontroller-operated and ground wheel-driven planters, respectively. Statistical analysis using t-test indicated significance at less than 1% level for effective field capacity, missing index, and multiple index (refer to Table 9). Consequently, it can be inferred that the microcontroller-operated planter outperformed the mechanical (ground wheel-driven) planter significantly.

Table 8. Analysis of variance of Quality feed index for different forward speeds

Source	Sum of Squares	df	Mean Square	F Value	p-value	Prob > F
Model	829.52	2	414.76	754.1091	< 0.0001	significant
A-speed	829.52	2	414.76	754.1091	< 0.0001	
Pure Error	3.3	6	0.55			
Cor Total	832.82	8				

Table 9. T test results of microcontroller operated planter and mechanical (ground wheel driven planter)

Statistics	Effective field capacity	Missing index	Multiple index	Quality feed index
Mean	0.36	6.28	10.33	83.39
Standard Error	0.005	0.925	0.778	1.492
T test	5.7	10.1	12.4	13.1
t critical	2.1	2.1	2.1	1.7
Probability	p<0.0001	p<0.0001	p<0.0001	p<0.0001

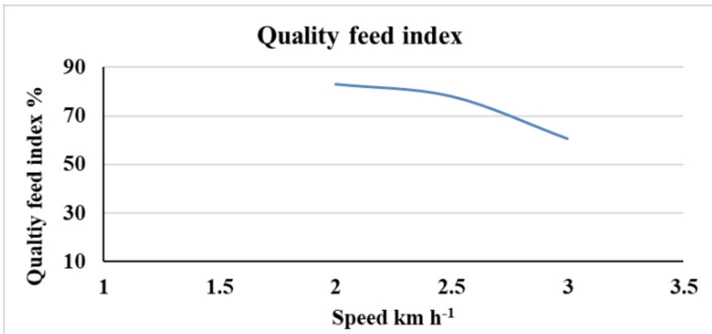

Fig.14. Effect of forward speed(kmh^{-1}) on quality feed index (%)

Cost analysis

The cost of operation of sowing with microcontroller operated planter and ground wheel driven planter was observed as Rs. 1,917 per hectare and Rs. 2,363 per hectare for maize crop. It was observed that when sowing was done with micro controller operated planter, there was a net savings of 20% of cost over ground wheel driven planter.

Conclusion

A microcontroller operated planter was developed at AICRP on FIM Scheme, Hyderabad its performance was evaluated against ground wheel driven planter The micro controller operated planter lead to reduction in missing index and multiple index by 67.48% and 57.08% respectively. It was observed that increase in quality feed index by 32.37% over ground wheel driven planter and it was also observed that when sowing was done with micro controller operated planter, there was a net saving of 20% of cost over ground wheel driven planter.

Future Scope of Work

This planter can be used for sowing with others bold seeds and the result can be compared to pneumatic planter.

Conflict of interest: None

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References

1. Cay, A., Kocabiyik, H. and May, S., Development of an electro-mechanic control system for seed-metering unit of single seed corn planters Part I: Design and laboratory simulation. *Computers and Electronics in Agriculture*,2018,144,pp.71-79.

2. McBratney,A., Whelan,B., Ancev, T. and Bouma, J. Future directions of precision agriculture. *Precision agriculture,*2006, 6(1),7-23.

3. Kamgar, S., Noei-Khodabadi, F. and Shafaei, S.M. Design, development and field assessment of a controlled seed-metering unit to be used in grain drills for direct seeding of wheat. *Information Processing in Agriculture*,2015, *2*(3-4), pp.169-176.

4. Karayel, D. Performance of a modified precision vacuum seeder for no-till sowing of maize and soybean. *Soil and Tillage Research*, 2009, *104*(1), pp.121-125.

5. Jayan.P.R and Kumar.V.J.F. Planter design in relation to the physical properties of seeds. *Journal of tropical agriculture*.2004. 42(1-2).

6. Inderpal Singh, Anand Gautam, Anoop Kumar Dixit, Gursahib Singh Manes and Arshdeep Singh., Development and Evaluation of Inclined Plate Metering Mechanism for the Sowing of Maize (*Zeamays*L) Seed. *Current Journal of Applied Science and Technology.* 2020, 39(13):118-128.

7. Rahim ADA. Dimension, geometric, Agricultural and Quality characteristics Of Safflower Seeds*. Turkish Journal of Field Crops* 2014, 19(1), 7-12.

8. Pittala Rajaiah, Indra Mani, Adarsh Kumar, Satish D. Lande, Ashok Kumar Singh and Cini Vergese. Development and evaluation of electronically controlled precision seed metering device for direct seeded paddy planter. *Indian Journal of Agricultural Research*., 2016, 86 (5): 598-604.

9. Z. Yasmeen, G. Sadique, M. Ashraf, U. Yaseen, M. Ahmad and S. Ahmad. Design development and Performance Evaluation of manually Operated Garlic Planter. *J. Glob. Innov. Agric. Soc. Sci*., 2018, 6(1):16-22.

10. Singh, T.P. and Mane, D.M. (2011). Development and Laboratory performance of an electronically controlled Metering Mechanism for Okra seed. *Agric. Mechanization Asia, Africa & Latin America*, 42(2): 63-69.

11. Singh K, Agrawal KN, Dubey AK, Chandra M P (2012) Development of the controller-based seed cum fertilizer drill. In: 12th *International conference on intelligent systems design and applications* (ISDA) (pp 369–374). IEE