**Performance of an Electrically Controlled Fertilizer Metering Mechanism for Horticultural Crops**

**Abstract:**

Sowing and fertilizer application to the both agricultural and horticultural crop is one of the most important operations in crop production that involves factors like correct seed rate, appropriate depth of placement and required fertilizer application for maximizing crop yield. The existing seeders and fertilizer applicators are require high energy and produce more vibration during operation and are expensive. An electrically controlled metering mechanism was developed the aim of development mechanism was to application of fertilizers to the horticultural crops. It can supply the fertilizer required quantity accurately two adjacent sides of the orchard palm. In mini seed drill the spokes wheel has been replaced by a 24 V DC motor operating through pulse width modulation (PWM) voltage regulator. In the modified system fertilizer metering shaft rotates ranges 80-120 RPM based on DC PWM voltage regulator. Maximum fertilizer delivery was recorded i.e., low discharge rate observed at 80 RPM 100 g and high discharge rate is 200 RPM 500g. Similarly the fertilizer rate variation was found to be 1.75±1.53% over the set values.

*Key words: Fertilizer applicator, Battery operated, DC Motor, PWM Voltage regulator, Fertilizer discharge.*

**1. INTRODUCTION**

Horticulture sector has become one of the major drives of growth in the agriculture sector. The horticulture crops include fruits, vegetables, spices, plantation crops and flowers. The percentage share of horticulture crops in value of total agriculture output is around thirty percent. The total horticulture production has increased from 21.2 metric tonnes (MT) in 2007-08 to 306.8 in 2017-18. It is a matter of pride that India is the second largest producer of vegetables and fruits in the world. The country ranks at first position in the production of banana, mango, lime and lemon, papaya, and okra In India area under horticulture crops raised by 2.6 percent per annum and annual production increased by 4.8% during 2017-18 (Anonymous 2019). Fruits and vegetables account for nearly 90 per cent of total horticulture production in the country (Krishna, *et al.*2024).

The application of fertilizers on orchard tree is a fairly tremendous process. It includes digging of a basin of proper dimensions and adding fertilizers in that basin in desired amount. The procedures used for the fertilization are relatively ancient. Advanced technologies do exist for this application but they find their uses in a very limited scope mainly because of their high initial cost and non-feasible nature (Srinivas *et.al* 2020). Fertilizer is generally applied manually in circular basins from base of the stem palm at a depth of 10 cm. The fertilizer rates to be applied first 2-3 years of orchards 100 grams of N, 100 grams of P and 100 grams of K in some areas formers used single super phosphate 14-35-35 and urea are used yearly trice (Singh 2020). The fertilizer requirement and basin diameter was increases according the growth stages of orchards (Anonymous 2016). Fertilizer drills facilitate line by line proper application fertilizer in the field crops. Many types of fertilizer application after intercultural operation have been developed to save time, fuel and irrigation expenses. The problem with existing fertilizer is that they drawn power from ground wheel. This wheel which many times get slipped and the required quantity is not dropped and this variation is in the range of 15 to 20%. The mechanism which distributes and delivers the fertilizer from the hopper to the specified place at selected rates.

Existing fertilizer metering units are not capable of efficient metering and placement of fertilizers required quantity and application rate once fixed are not uniform and consistent throughout the field because of skidding of ground drive wheel and inefficient metering mechanisms. The present practice of over fertilizer and subsequent thinning leads to higher cost of production. New approach based on requirement the electronic metering mechanism. It was decided to develop an electronic controlled DC motor driven cup type metering device to be used in planters for accurate placement of seed. This would also eliminate the mechanical power transmission system commonly used to drive the seed metering device from the lug wheel, thus, making the drills/planters simpler.

**2. MATERIALS AND METHODS**

 Tractor battery operated fertilizer applicator was developed at the Department of Agricultural Engineering, Regional Agricultural Research Station Tirupati. The major component of the developed machine includes main frame, fertilizer hopper, edge cell type metering unit, two out lets for fertilizer conveying to the plant, DC Motor, DC Voltage regulator, connected lines with clips and tractor battery.

**2.1 Fertilizer Hopper**

In this experiment, existing seed cum fertilizer drill modified single fertilizer hopper with 2 delivery tubes it can deliver the two adjacent side of the plant. The vertical edge cell type metering mechanisms were located on a meter drive shaft. The drill row spacing was 10 cm. The power for the seed meter drive shaft was provided by drive from the DC motor.

**2.2 DC Motor**

 A 12 V, 200 rpm geared DC motor was used to operate the fertilizer metering shaft. The DC motor was mounted on the frame. The wired connection accomplished from tractor battery through the DC Voltage regulator. Below table show specifications of the dc motor

(Singh *et al,* 2020). Table 1 show specifications of the DC motor.



**Fig. 1. DC Motor for rotating the fertilizer metering shaft**

**Table.1 Specifications of DC motor**

|  |  |
| --- | --- |
| **Parameter** | **Description** |
| Name  | xcluma |
| Type | Geared |
| Max RPM | 200 |
| Min RPM | 180 |
| Voltage  | 12 V |
| Torque | 8.15 kg-cm |

**2.3 PWM DC Voltage Regulator and Auto timer cut off switch**

 The PWM (Pulse Width Modulation) DC motor speed can be regulated using DC voltage regulator. The 20A PWM DC motor speed regulator module (100, 80, 60 and 40 %) is suitable for the DC motor. It comes with the metal shell and connective label, which makes it very easy to install and use. It has a potentiometer with an adjust speed switch function, and button switch function. Connection made red and blue wire line connect to tractor battery through auto timer cutoff switch and black and green line DC Motor shown in Fig.1.

 The auto timer cutoff switch adjustable 10 sec to 20 minutes with12V used for operating DC motor through PWM voltage regulator. Manually set times on module so that it can on and off the DC motor.



**Fig. 2. PWM DC Voltage regulator**

**2.4 Power Transmission to the Fertilizer Applicator**

The power transmitted from battery to the fertilizer metering shaft through the DC Voltage regulator and DC motor. The power transmission of fertilizer applicator was shown Fig.3. The Block Diagram of power transmission to the fertilizer applicator is shown in Fig..4.



**Fig. 3. Power Transmission to the fertilizer applicator**



**Fig. 4 Block Diagram of power transmission to the fertilizer applicator**

**2.5 Calibration**

 In order to study the effect on fertilizer discharge and variation between the fertilizer tubes of fertilizer metering shaft speed, DC motor speed, DC regulator and different levels of fertilizer hopper filling laboratory evaluation were carried out. The developed fertilizer applicator was tested at desired levels of operational parameters to determine the various factors affecting the performance. Based on the results and optimized values, a prototype round basin making cum fertilizer applicator developed and was evaluated in the field with the optimized operational parameters. The operation of the developed unit was independent of forward speed of the prime mover. The details specifications of fertilizer application unit shown in Table 2.. (Tripathi A.K. 2025)

**Table 2 Specifications of Fertilizer application unit**

|  |  |
| --- | --- |
| **Parameters**  | **Particulars** |
| Type of planting unit | Vertical rotar cell edge type |
| Volume of fertilizer box | 33750 cm3 |
| Power transmission | DC motor |
| Fertilizer carrying tube | 2 |
| Flow control device | PWM voltage regulator |
| Max Speed of DC motor | 200 rpm |

**2.6 Statistical Analysis**

 The data obtained from the experiments of fertilizer applicator were statistically analysed by descriptive statistical analysis method using IBM SPSS 2022 (Statistical Package for Social Sciences) software. The effect of selected equipment parameters over the performance of laboratory model as well as final prototype are noted. The analysis of variance (ANOVA), mean tables, lack of fit and interactions between the subjects for different physical, biometric and performance parameters were tabulated and the level of significance was reported. The degree of freedom (df) and R squared values were reported.Different variables considered for optimization of fertilizer applicator shown in table..3. (Tejaswini, *et al.*2025)

**Table.3 Different variables considered for optimization of fertilizer applicator**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Treatment** | **No. of levels** | **Particulars** |
| 1 | PWM DC regulator supplying voltage ( %) | 4 | 100, 80, 60 and 40 % |
| 2 | Metering shaft speed (RPM) | 4 | 80,120,160 and 200  |
| 3 | Level of fertilizer hopper filling | 4 | 1/4,1/2,1/3and hopper full Level |
| No. of replications  | 3 |
| Total No. of experiments = 4\*4\*4\*3 | 192 |

**3. RESULTS AND DISCUSSION**

**3.1 Laboratory Evaluation of Fertilizer Applicator**

 The independent variables were selected for testing and optimization of fertilizer applicator. Equipment were carried out in the laboratory to examine the fertilizer delivery rate by keeping equipment stationary. The fertilizer applicator was tested at different fertilizer metering shaft 80,120,160 and 200 RPM amount of fertilizer delivered was measured. Measured DC motor speed at different voltages of PWM voltage regulator (i.e. 100, 80, 60 and 40 %). Using auto timer cutoff switch time was fixed to 30 seconds. After 30 seconds speed of fertilizer metering shaft was stopped due cutoff switch restrict passes of voltage.

**3.2 Effect of DC Regulator on Fertilizer Metering Shaft**

The speed of fertilizer metering shaft varies based on the DC regulator. The voltage ranges from 100, 80, 60 and 40 %. Average speed of fertilizer metering shaft was calculated and tabulated for different combinations. Based on the experimental results, the speed of the fertilizer metering shaft was recorded at 80 RPM when operating at 40 % of the DC voltage, and 200 RPM at 100 % of the DC voltage, as illustrated in Fig.5.

**Fig.5 Effect voltage of DC regulator on speed of fertilizer metering shaft**

**3.3 Effect Speed of Fertilizer Metering Shaft on Discharge Rate**

The fertilizer discharge rate was influenced by speed of fertilizer metering shaft. The speed of metering shaft was 80, 120, 160 and 200 RPM. Average discharge of fertilizer was calculated and tabulated for different combinations. It was observed that the minimum weight 111.4 g and maximum weight 474 g was obtained at 80 and 200 RPM speed of fertilizer metering shaft respectively. The values were represented in Table4. The effect speed of fertilizer metering shaft on discharge rate shown in Fig.6.

**Fig.6 Effect speed of fertilizer metering shaft on discharge rate**

**3.4 Effect Speed of Fertilizer Discharge on Different levels of Hopper Filling**

The amount of fertilizer collected from two different rows obtained different fertilizer hopper filling at different metering shaft speed are shown in Figure 7. It is observed that low weight is obtained from 80 RPM at 1/4th of hopper filling i.e., 70 g and high weight 500 g obtained from hopper full filling at 200 RPM.

 **Fig.7 Effect speed of fertilizer discharge on different levels of hopper filling**

**3.5 Conclusion from Laboratory Evaluation of Fertilizer Applicator**

From laboratory studies, the overal PWM voltage regulator, fertilizer metering shaft speed, and different level of hopper filling with 2 fertilizer discharge outlets were found satisfactory. Average recommended dose as fertilizers (Anonymous 2018). The fertilizers used for growth of horticultural crops are urea, rock phosphate and muriate of potash. Based on the requirement the speed of fertilizer metering shaft through DC voltage regulator**.**

Results from laboratory evaluation indicate the performance of all the speeds under various experimental conditions. Operating the PWM Voltage regulator at 40 % of DC voltage and fertilizer metering shaft will rotate through the DC motor speed of 79.67 RPM equal to 80 RPM with an fertilizer discharge per 30 second in two delivery tubes around 111.74 g min-1, coefficient of variation of 0.06 per cent. The voltage increases PWM Voltage regulator at 100 % of DC voltage and fertilizer metering shaft will rotate through the DC motor speed of 198.67 RPM equal to 200 RPM with an fertilizer discharge per 30 second in two delivery tubes around 474 g min-1, coefficient of variation of 0.04 percent. Hence it is concluded that increases the fertilizer discharge rate by increasing the PMW voltage regulator voltage and fertilizer metering shaft speed. The level of fertilizer hopper filling is also effect fertilizer discharge rate.

**Table.4. Constrains data of laboratory evaluation of fertilizer applicator**

|  |  |  |
| --- | --- | --- |
| **DC Voltage (%)** | **DC Motor Speed RPM** | **Fertilizer discharge rate per 30 seconds in two delivery tubes** |
|  | **M** | **SD** | **CV** | **M** | **SD** | **CV** |
|  **40** | 79.67 | 7.40 | 0.09 | 111.4 | 7.40 | 0.06 |
| **60** | 117.67 | 8.40 | 0.07 | 225 | 11.18 | 0.04 |
| **80** | 157.67 | 9.40 | 0.06 | 323 | 17.88 | 0.05 |
| **100** | 198.67 | 10.40 | 0.05 | 474 | 20.73 | 0.04 |

**CONCLUSION**

The optimal operational parameters, tests were conducted to assess the impact of a round basin maker combined with a fertilizer applicator.The speed of the fertilizer metering shaft is 80 RPM at PWM regulator 40 % of voltage and 200 RPM at PWM regulator 100 % of voltage respectively. The auto timer cutoff switch adjustable 10 sec to 20 minutes with 12V used for operating DC motor through PWM voltage regulator. Manually set times on module so that it can on and off the DC motor. The maximum fertilizer discharge per 30 seconds time interval in two fertilizer delivery tubes around 474 g per 30 seconds, coefficient of variation of 0.04 %.

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