# Microcontrollerimplementationinprecisionplanting:Areview


## Abstract

Precision farming, also known as precision agriculture, is a crop management method thatoptimizes agricultural production by utilizing technology and data for precise placement ofseed, fertilizer and pesticides. It enhances increase crop yields, reduce waste, and reduceenvironmental impact by applying the appropriate amount of inputs, such as seed, water,fertilizer, and pesticides for each crop. Farmers can reduce expenses by reducing the usage ofexpensive inputs while increasing yields and crop quality by employing precision farmingtechniques.Commerciallyavailableplantersnormallyusemechanicalmeteringsystemswhichhavemanylimitationsincluding,skiddingofthewheel,non-uniformseedrate,wastage of the seed and higher maintenance cost. It is evident from recent researchers thatirregularly in seed placement, which is generally caused due to wheel slippage and seedmeteringsystemspoweredbyelectricorhydraulicmotorcanmaintainaccurateseedplacementandcanworkathigherspeedscomparedtotraditionalplanters.



**Keywords:Precisionplanting,Microcontroller,Sensorand Automation**


## Introduction

A planting machine's main goal is to plant seeds at a specific depth and spacing insidea row. Seed metering devices include fluted feed type, internal double run type, cup feedtype, inclined plate type, cell feed type, brush feed type, auger feed type, picker wheel type,andvariableorificetypeinseeddrillsorplanters.**(Varshney*etal*.2004).**Theseapparatusesusuallyneedagroundwheelfortransmissionofthepower,andasconsequence,plantingaccuratenesscannotbesafeguardedbecauseofthepresenceofground wheel slippage and chain vibration especially at higher forward speeds (**Lie *et al*.2015**).

Severaltypesofplantersandseeddrillshavebeendevelopedbuttheproblemcontinues, like the missing of seeds, overfilling (**Baral *et al*. 2019).** Mechanical meteringmechanisms have proved to be supportive, but they do not provide desired precision andcause an excess in seed due to the loss in mechanical transmission **(Aware and Aware,2014).** Another drawback of mechanical metering devices is the bulkiness of the system.Inamechanicallydrivensystem,thereisthelackofcommunicationofseedplacementbetwe en row-unit on an implement. The Mechanical driven system regulates mainly theseeding population, but not the actual timing and placement of the seeds **(Iacomi andPopescu, 2015).** It is observed during operation, that factors such as crop residues, stubblesin thefield, uneven topography, and high resistant torque on the ground drive wheel resultinthenegative slippageofthegroundwheel**(Namdeo*etal*.2020**).

**Kepner *et al.* (1987)** demonstrated that non-uniform seed placement would reducefinalcropyield.Microcontrollerseedmeteringmechanismworkswithasensor-builtelectronic metering system, which improves precision to the work. In this case, the seed ratecan be easily controlled with the rpm controller and can be used for a variety of seeds with achange in the seed metering plate, and an electronic metering mechanism may be one of theoptionstoachieveaccurateseedspacingwithhigherefficiency(**Koley*etal*.2017**).

## Workingprincipleandcomponentsofelectronicsowing/plantingsystem

Theelectronicssystemworksontheconceptthattheshaftencoderdetectstheforward speed and sends signals to the microcontroller in digital code. The microprocessorsynchronizes the forward speed of operation with the metering mechanism plate in a 1:1transmissionratio.Themicroprocessorsendssignalstomotordrivermodule,whichiscoupledtot herotatingelectricmotor(Fig.1).

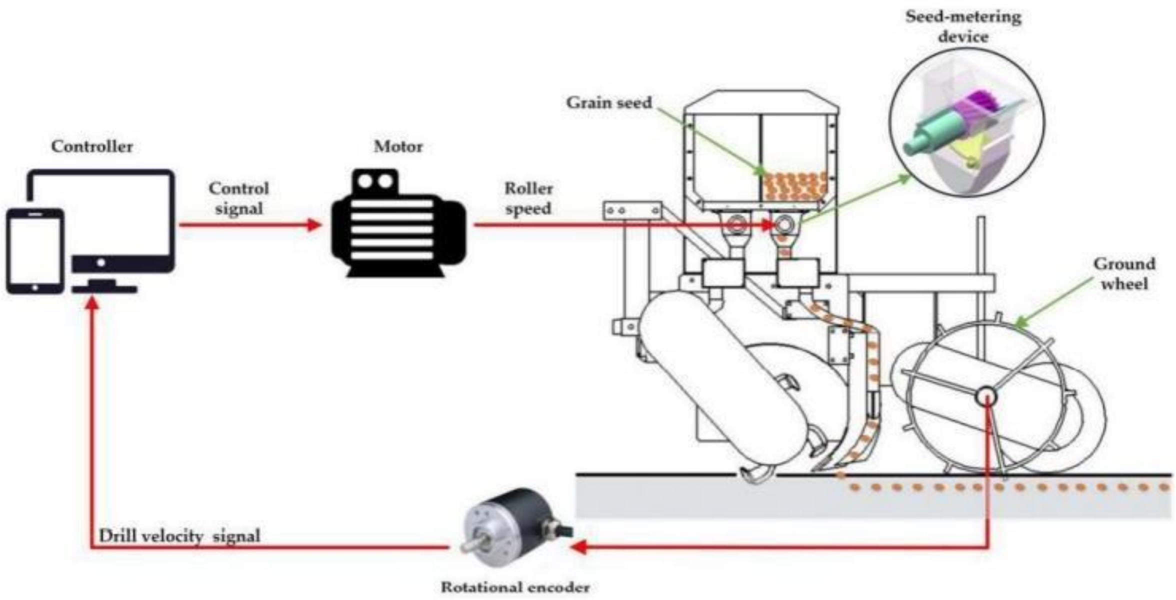


**Figure1.**Componentsoftheelectronicsseedmeteringsystem(**Liu** ***et al*****.2020**).

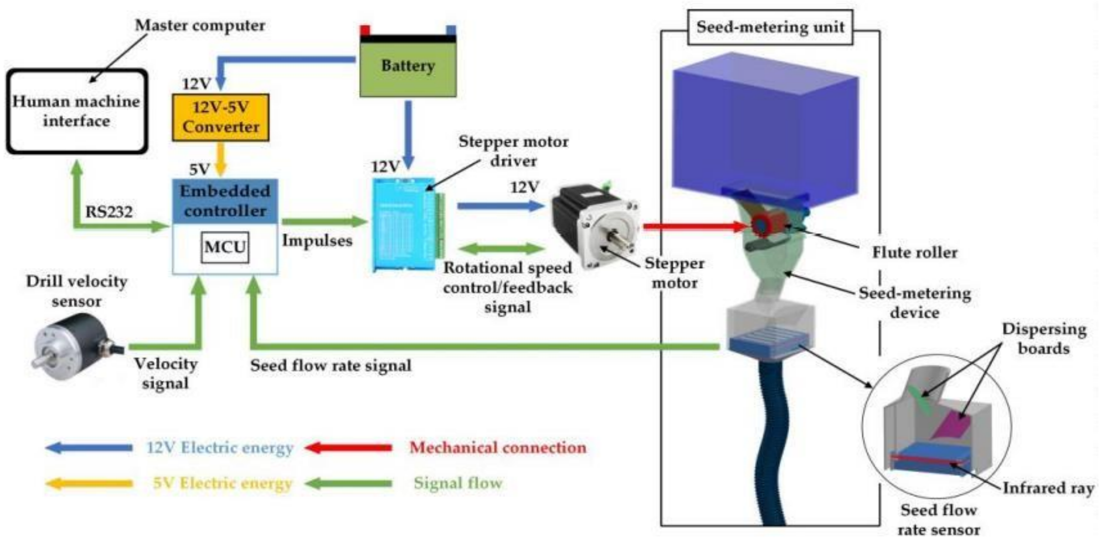


**Figure 2.** Schematic view of the adaptive seed metering speed control system for a seed-meteringunit(**Liu*etal*.2020).**

**Liu** ***et al*****. (2020)** developed a mechatronic system for a uniformity of the seed spacingthat includes an Embedded controller, shaft encoder for measuring travel speed, electricmotors,seed box,seed meters,and powersupply (Fig.2). The Mechatronics system ispowered by a 12-volt tractor battery. An incremental encoder mounted on the shaft of aground wheel measures the value of travel speed. The encoder emits matching pulses inresponsetotherotationofthegroundwheel,whichthecontrollercanusetocomputetravel speed by counting the number of pulses received in a given amount of time. Brushless DCmotors with three Hall-effect sensors attached on the back for monitoring the positions of theU,V,andWrotorsenablecurrentswitchingfortherotors.

To achieve closed loop control, the three Hall-effect sensors measure the motor speedin real time. The number of seeds can be judged according to the time when the falling seedsshaded the infrared ray.A master computer allows for the inputting of parameters such asseed spacing, wheel slip ratio, ground wheel diameter, and number of seed holes per disc, aswell as the display of travel speed and seed plate rotation speed, as well as the sounding ofalerts in the event of a system fault. The controller's primary role is to generate a pulse signalwith a specific frequency and duty cycle to control seed plate rotation speed dependent ontravelspeedinordertoensureuniformseedspacing.

## Analysisofthemeteringmechanism'sperformance

The fraction of seed spacings that are greater than or equal to 1.5 times the nominalseed spacing is known as the missing-seeding index ($I_{miss}$), which shows the percentage ofmissed seed sites or skips. Multiple index ($I_{mult}$) includes two or more seeds picked anddropped by the seed metering unit through a single groove in the metering plate, it is thepercentage of seed spacing less than or equal to 0.5 nominal seed spacing. The percentage ofseed spacing that is more than half but not more than 1.5 times the nominal spacing is knownas the quality of feeding index ($I_{qf}$), and it reflects the percentages of single seed drops. Afterexcluding outliers such asmissing-seeding and multiples,precisionindex ($I_p$)is defined asthe coefficient of variation of the spacing (length) between the nearest seeds in a row that areclassifiedassingles.$I_{miss}$,$I_{mult}$.$I_{qf}$and$I_p$can becalculatedusingequation 1,2,3and4respectively**(Singh*etal.*2012andLi*etal.*2015).**

$$I_{Miss} = \frac{n1}{N} \quad \ldots (1)$$

$$I_{Mult} = \frac{n2}{N} \quad \ldots (2)$$

$$I_{gf} = 100 - (I_{miss} + I_{mult}) \quad \ldots (3)$$

$$I_p = \frac{S_d}{S} \quad \ldots (4)$$

Where

$n_1$isnumber

ofspacing>1.5S,$n_2$isnumberofs

pacing≤0.5S

N is total number of measured

spacing$I_{QFI}$ispercentageofqualityoffeedin

dex

$S_d$isstandarddeviationofthespacingmorethanhalfbutnotmorethan1.5timesthesetspacingSinmm.

The research undertaken has been reviewed and more than 100 research papers/articles havebeen studied. The important researches undertaken by various researchers on electronic seedmeteringmechanism and use of agricultural robots for seeding operations have summarizedin Table 1 and 2 respectively. In addition, results of relevant studies on electronic meteringhave been summarized in Table 3.

**Table1**.Electronicseedmetering mechanism

| **Description** | **Majorfindings** |
| --- | --- |

| | |
|---|---|
| Amicroprocessor-controlledplanter **(WilkinsandLenker,1981).** | Incomparisontoacommercialvegetableplanter, laboratorytestsonagreasedbeltrevealedthatthe microprocessor-controlledplanter metered raw lettuce seeds with fewererrors. |
| Opto-electronicsensorsystemforrapidevaluation of planter seed spacing uniformity**(Kocher*etal.*1998)** | Theopto-electronicsystemcanbeusedinstead of a grease belt test stand to rapidlyobtain quantitative evaluation of planter seedspacing uniformityinthelaboratory. |
| Opto-electronic sensor system for laboratorymeasurementofplanterseedspacing withsmallseeds**(Lan*etal.* 1999)** | Theopto-electronicsensorsystemmissedtwo seeds and detected two planter seeds outof170seedspacingwiththemediumencrustedsugarbeetseed. |
| Developmentofproximitydistancesensorbased electronicmeteringmechanismforthree row planter(**Aware *etal.*2008**) | Developedelectronicplanterwastestedinthe laboratory. It was necessary to keep thetractorspeedconstantinordertoachievethe desiredplantto plantspacing. |

| | |
|---|---|
| Development and functional test of electronicmeteringmechanismforbullockdrawnjyotimulticrop planter(**Shinde*et al*.2009).** | Discussesvariouselectronicseedmeteringmechanism components operations; distancesensing unit, check valve activating systemwithamicroprocessor,softwareprogram,andsolenoidswitcheswiththeirfuturepossibilities. |
| Performance monitoring system for precisionplanter based on MSP430-CT171 (**Xia *et al*.2010).** | 100% of thesound-lightalarm system andthephotoelectricsensorcoulddetectmorethan95%seedspassedit. |
| Development of an optoelectronic monitoringsystem forcrop planterseedmetering unit(**Hajahmed*etal*.2011).** | Brieflyexplainstheapplicationofanoptoelectronicsensor,rotaryencoder,amplifiers,microcontroller,and PC. |
| Development and laboratory performance ofanelectronicallycontrolledmeteringmechanism for okra seed **(Singh and Mane,2011).** | Deliberatesthedevelopedelectronicallycontrolledseedmeteringmechanismachievedsensiblyanddeliveredtheseedsquitecloser tothetargetseedspacings. |
| Developmentofthecontroller-basedseedcumfertilizerdrill(**Singh*etal*.2012).** | Abriefreviewofprecisionfarmingtechnologies basedonmicroprocessoranddecision support systems for enhancing inputapplicationefficiencyinproductionagriculture. |
| Design,developmentandevaluationofamechatronictransmissionsystemforupgrading performance of a row crop planter(**KamgarandEslami,2012).** | Resultsoffieldevaluationshowedthatmechatronics mechanism decreased multipleindex,higherpercentage in quality of feedindexforplanterequippedwithmechatronic mechanismand rubbertire. |

| | |
|---|---|
| Design and experimental study of the controlsystemforprecisionseed-meteringdevice(**Jianbo*etal*.2014).** | The technology would vastly enhance sowingquality,lowerleakageseedingrates,and boostoutput. |
| Anewconceptforseedprecisionplanting **(IacomiandPopescu,2015)** | Electronicallycontrolledseedsingulationdeviceshaveapotentialtoincreaseproductivityandyielddramaticallyoveramechanicalseedmetering mechanism. |
| Design, Development and field assessment ofa controlled seed metering unit to be used ingraindrillsfordirectseedingofwheat(**Kamgar*etal*.2015).** | Usingaconstructedseedmeteringdeviceinaseed drill, precision seeding for the highestforward speed (8 km/h) was obtained in thefieldwithvariouslevelsofstubblecoverage. |
| An embedded system for detecting seed flowin the delivery tube of a seed drill **(RahemanandKumar,2015)** | The performance of the developed embeddedsystemwasevaluatedusingalaboratorysetup atdifferentseed flow rate for wheatandragiseeds. |
| Electro-mechaniccontrolsystemforpneumaticprecisioncornplanters(**Kocabiyik*etal.*2016).** | Pneumaticprecisioncornplantermodifiedwith the electro-mechanic control system wastested and found sufficient for corn seeds inthis work. |
| Optimizeddesignandperformanceevaluationof anelectriccup-chainpotatometering device**(Kang*etal*.2017).** | Briefly explains the electronic control systeminsteadofagroundwheel drivenchaintoenablefastseedingandpreciseintra-rowseedingdistance. |
| Developmentofelectronicmeteringmechanism forprecisionplantingofseeds**(Koley*etal.*2017)** | The seed breakage was found minimum at alowermeteringplaterpm.Seedtoseedspacingwasfoundtodecreasewithan increaseinmeteringplatespeed. |

| | |
|---|---|
| Detectionofflowofseedsintheseeddelivery tube and choking of boot of a seeddrill**(KumarandRaheman,2018).** | Thedevelopedsystemcouldproducebothvisual andaudiblesignalstowarntheoperatorforsuccessfulshowingofwheatseeds both in the laboratory setup and also ina 9-rowtractordrawnseeddrill. |
| Developmentoftractordrawnelectronicmulti-cropplantercumfertilizerapplicatorforprecisionfarming**(Baral*et al*.2019)** | The sensor system in the machine helps inproper metering of the seeds and thus furtherreducesthelosses. |
| Microcontroller based seed metering systemfor precise soyabean seeding **(Namdeo*et al*.2020)** | Electronic seed metering system enabled thesuggested optimum seeding rate, a quick andsimplesettingpossibility,synchronizeandreal time control, the ability to work underhigherspeeds. |
| Designandtestingofnovalseedmissprevention system for single seed precisionmetering device**(Nikolay*etal.*2022)** | The analysis of experimental results showedno occurring misses at the seed release pointwhenthesystemwas used. |
| Development of a single-row push type plotseeder with mechatronic seed feeding devicefor (*Zea Mays L*.) field breeding experiment**(Tabal*etal*.2022)** | The machine was equipped with mechatronicseed feeding device to provide an efficientway of sowing for every plot and economicalmachineforlowerstagecornfieldbreeding experiment. |

**Table2.**Researchonagriculturalrobotsforseedingoperation

| Reference | Description |
|---|---|
| Useofroboticstechnologyfor seedsowinginagriculture**(Swati*etal.*2015).** | The energy required for this robot equipmentislessthanthatrequiredforhumanand tractor-basedsowing.Thereisalsoreduced seedwaste. |
| Precisionagriculturerobot forseedingfunction**(Naik*etal.*2016)** | Developedrobot,workingisbasedontheprecisio n agriculture which enables efficientseed sowing at optimal depth and at optimaldistancebetweencropandtheirrows,spe cificforeachcroptype. |
| Designofanautonomousseed planting robot **(Srinivasan*etal*.2016)** | Seedmeteringmechanismdeviceexhibitsappre ciable efficiency in power consumption,making it suitable for the field of agriculture. |
| Automatedseed sowing agribotusingArduino**(UmarkarandKarwankar, 2016).** | Theeffectsofseedplantingoperatio nsarepreciselyobservedutilizingvariousgroun dcontoursandperformsdigging,sowingthe seed and coverstheground byclosingit. |
| Designanddevelopmentofagribotforse eding**(Pavan*etal*.2017).** | Theseseedingrobots canbeutilizedformassplantation,reforestation, andafforestationin additiontothe agriculturalprocess. |
| Roboticvehiclefor seed planting andweedingapplication**(MuleyandKandlikar,2017).** | It carries out the basic activities of farming,such asploughingthefield,sowingseeds,andcoverin gthe seeds withsoil. |
| Sensorandvisionbasedautonomousagribotfor sowingseeds**(Santhi*etal.* 2017)** | The proposed robot is a micro planter whoseprimarytaskwouldbetosowseedsatprefi xedseedingintervalsinthefield. |

| | |
|---|---|
| Designandimplementationofautomaticseedsowingrobot**(Chame*etal*.2018).** | Itrelievesthefarmerofsomeofhisresponsibilities, and the robot will accuratelyplacetheseedintheproperfieldwithoutthe needforhumanintervention. |

| | |
|---|---|
| Autonomousseedsowingagriculturerobot **(Jayakrishna*etal.*2018)** | Developed robot requires less human effortand time with less cost of implementation insuchrequiredforsuccessinagricultureindustry. |
| Solar powered autonomous multipurposeagriculturalrobot usingBluetooth/androidapp**(Ranjitha*etal.* 2019)** | Developedrobotincreasetheefficiencyofseedsowing,pesticidesprayingandgrasscuttingandalsoreducestheproblemencounteredinmanualplanting. |
| Designandfabricationofsmartseedsowingrobot**(KumarandAshok,2020).** | Usingacleverlybuiltmechanicalmechanism, this technology totally automatesthe seed sowing procedure. As the seeds aresown, this robot decreases the work and totalcostofsowing. |
| Designofautomated seed sowingrobot forBTcottonseed**(Nagdeva*etal.*2020)** | DesignandtheworkingprocedureoftheseedsowingmechanismanditsvariouscomponentsinvolvedforthesuccessfulsowingoftheBTcottonseedbytherobot. |
| Fogcomputing -basedseedsowingrobotsforagriculture**(Lachureand Doriya,2021)** | FastAimethodandmachinelearningtechniquesareusedtoclassifythewheatdatasetintodifferentclasseswithhighaccuracy. |
| Arduinoboard-basedwirelesscontrolledseedsowingrobot**(Sugade*etal.* 2021)** | Robot can manage to plant the seed up to 2-5cm depth.Differenttasksoftherobotarecontrolled by an android application installedonasmartphone. |
| Automated seed sowing robot **(Vimal *et al*.2021)** | Developedequipmentweusedploughingrod, water pump and seed sower with landlevellingattachment. |
| | Robot that can solve such problem measurethedistancebetweenseedthatleadtosav |

Designanddevelopmentanagriculturerobotfor e
seedsowing,watersprayandfertigation

| | |
|---|---|
| **(Fadhaeel*etal.*2022)** | wastageofwater,determinedtheplantsneedsoff ertilizerbyusingsoilPH sensor. |
| Designofautomaticseedsowingmachineforagr iculture sector**(Kumar*etal.*2022)** | Developedmachineaimstoautomateahighlylab or-intensivetaskforfarmerslackingthefinancingre sourcestoaffordtraditionalfarmmachinery. |
| Lotbasedsmartagricultureandautomaticseedso wingrobot **(Narasimman*etal.* 2022)** | The ultimate objective of seed planting usingimprovesowingequipmentistoachievepr eciseseed distributionwithin the row. |
| Designanddevelopmentofsolarpoweredaut onomousseedsowingrobot**(Shanmugasun dar*etal.*2022)** | Aploughingmachineisattachedtothemachine, which digs the soil for sowing andthen,seedsaresowedonthebasisof the revolutionofthe wheel. |

**Table.3**Resultscollectedfromseveralelectronicstudies

| | | **Results** | | | |
|---|---|---|---|---|---|
| **Reference** | **Speed ($Km.h^{-1}$)** | **$I_{qf}$(%)** | **$I_{mult}$(%)** | **$I_{miss}$(%)** | **$I_p$(%)** |
| **OnalandOnal, 2009** | 1.8–7.2 | 91.30 | 2.90 | 5.80 | --- |
| **Taghinezhad*et al*.2013** | 0.9-3.6 | 89.72-93.43 | 2.52-7.23 | 2.81-7.26 | --- |
| **Li *etal*.2015** | 9–12 | 89.93–94.23 | --- | 2.49–5.03 | 17.85-18.80 |
| **Rajaiah *et al.* 2016** | 2.0 | 88.1 | --- | 6.1 | --- |
| **Chunling*etal*. 2017** | 10.0 | 92.04 | --- | 4.82 | --- |
| **He*etal*.2017** | 8.6-13 | 96.9-98.81 | --- | 1.19-3.1 | 14.38-16.04 |
| **Hao*etal*.2017** | 3-12 | 95.1-98.1 | 0.2-0.7 | 1-4.2 | --- |
| **Cay*etal*.2018** | 5-10 | 90.63 | 0-1.73 | 8.44 | 8.79-22.14 |
| **Thokale *et al.* 2019** | 4.5 | 89.93 | --- | 5.08 | 18.80 |

| | | | | | |
|---|---|---|---|---|---|
| **Khura** ***et al.*** **2019** | 0.65 | 89.54 | --- | --- | --- |
| **Hensh andRaheman,2022** | 0.84 | 93.75 | 0 | 6.25 | --- |
| **Wang** ***et al.*** **2022** | 5-13 | --- | --- | --- | 16.72 |
| **Gautam** ***et al.*** **2023** | 1.56 | 90 | --- | --- | --- |

## Summary ofresearchonelectronicseedmeteringsystem

The quality of feed index ($I_{qf}$) of the seed-metering device rapidly increased as theworking speed of the operation increased, with increasing miss index ($I_{miss}$) and precisionindex ($I_p$), and greater divergence from the average seeds spacing. With increasing speed, themultiple index ($I_{mult}$) reduces**.** According to the experiments, precision planters equipped withelectronics systems demonstrated higher seeding uniformity across all seeding technologies,with $I_{qf}$, $I_{miss}$, $I_{mult}$, and $I_p$ ranges between 88.1 and 98.81, 1 and 8.44, 0 and 7.23, and 8.79 and22.24%ranges,respectively,attravelspeedsof0.65to13kmh$^{-1}$(Table3).Thus,microcontroller-basedseedmetering system could be one of the possibilitiestoachieveproper seed spacing with increased planting/seeding efficiency and reduced due to increasedseedingspeed.

## Conclusions

Theadvantageofthemicrocontroller-basedseedmeteringmechanismismoreobviousespeciallywhentheoperatingspeedismorethan13kmh$^{-1}$.Precision index of the seed metering mechanism decreased with increase the operatingspeedofthemachine.Useofelectronicforseedmeteringmechanismmaybeoneoftheoptionstoachieveaccurate seedspacingwithhigherefficiency.Wearandtearofvariouspartscanbereducedconsiderablythroughuseof electronicseedmeteringsystem.Smartandautomatedsowingof seedusingarobotreducesthelaborrequirementandalsoreduces drudgeryassociatedwithplantingoperations.Tremendous time saving is possible through automation in sowing/weeding field,standard can be easily met and efficient and effective farming can be performed withincreasedproductivity.

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