AUTONOMOUS WEED CUTTER

TECHNICAL DESIGN REPORT
TCTD CHALLENGE
INTER IIT TECH MEET 2018

Submitted by: IIT Patna

INTRODUCTION

India is an agriculture-based country, where more than 50% of the population depends on farming. Indian agriculture sector accounts for 18% of India's Gross Domestic Product (GDP) and provides employment to 50% of the country's workforce. India's gross irrigated crop area of 82.6 million hectares (215.6 million acres) is the largest in the world.

The total production and economic value of horticultural produce (contributing to India's agriculture), such as fruits, vegetables, and flowers have doubled in India over the 10-year period from 2002 to 2012. The total horticulture produce reached 277.4 million metric tons in 2013, making India the second largest producer of horticultural products after China.

Common and major problems faced by farmers in India:

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Post Survey analysis:

After asking the farmers in areas nearby the college, the major areas of problems where they were exhausting a lot of money and scarcely available labor were found to be: *transplantation of germinated wheat and paddy grains;* ***removing of weeds grown in between the rows of crops, tree plantations****; use of herbicides (to eliminate the weeds) which affects the crop a lot; pests and insects that destroy the crops; issue of water required to irrigate the crops*; and many more.

Out of all the problems, one of the most significant problem was adjudged to be the problem of **weed removal** in crops and fields. Usage of herbicides harms the crops and plants. After the crop is harvested, the food grains are also affected by the chemicals that were used. Further, application of same herbicides gradually makes the weeds immune to that particular chemical which leads to the development of weed races or crop- relative weeds that become unresponsive to agricultural practices employed and dominate cultivated fields. Pollution of groundwater is possible when leachable herbicides are used. Certain herbicides have long half-life and persist in the environment for a long period of time that limits agricultural land uses. Few of the herbicides are also very costly, but farmers need to buy it in order to remove weeds. Moreover, the manual method of removal is highly inefficient, expensive and laborious. Concluding the survey, the problem that is addressed in this report is of weed removal.

Weed is a wild plant growing where it is not wanted and in competition with cultivated plants. Weeds compete with productive crops, ultimately converting productive land into unusable scrub. Weeds can be poisonous, distasteful, produce burrs, thorns or otherwise interfere with the use and management of desirable plants by contaminating harvests or interfering with livestock. Weeds can also host pests and diseases that can spread to cultivated crops.

EXISTING METHODS FOR WEED REMOVAL:

- **Manual removal:** Many gardeners still remove weeds by manually pulling them out of the ground, making sure to include the roots else that would allow them to re-sprout. This method is expensive and a lot of manual labor is required.
- **Thermal:** Flame weeders use a flame several centimeters away from the weeds to give them a sudden and severe heating. The goal of flame weeding is lethal wilting by denaturing proteins in the weed. Similarly, hot air weeders can heat up the seeds to the point of destroying them
- **Buried drip irrigation:** It involves burying drip tape in the subsurface near the planting bed, thereby limiting weeds access to water while also allowing crops to obtain moisture. It is most effective during dry periods. This method is expensive and can only be used in case of tree plantations.
- **Herbicides:** Weed control can also be achieved by the use of herbicides. Selective herbicides kill certain targets while leaving the desired crop relatively unharmed. Some of these acts by interfering with the growth of the weed and are often based on plant hormones. They effect crops and pollute the soil and water that is provided to plants.
- **Existing Mechanical Solutions:** Power weeders or weed cutters. These usually run on diesel or petrol consuming natural resources and causing pollution. They are a lot expensive and most important of all, they are not autonomous. They require a person to be present to operate the tool. Generally, the weeders cut the part of weed above the ground in spite of uprooting them. Large weed cutters, which are used as an accessory trailing behind a tractor, are also present, however, they can be used to remove weeds from the soil before crop plantation only and cannot remove weeds after plantation has been done. There is no efficient solution available to Indian farmers to remove weeds that grow in between the rows of crops except manual method as mentioned above.

OUR SOLUTION:

What we propose as a solution to this problem is an **Autonomous Weed Removal** machine that uproots the weed from and with its roots. Uprooted weeds eventually dry out to die from not getting the supply of nutrients thereby ending undesirable and adverse competition which it was giving to the crop being actually cultivated. The part which has been automated is the one which was previously (i.e. with the existing solutions) played by one or some farmers i.e. of holding and controlling the machine. Autonomous weed removal is once to be placed with proper alignment in nearly linearly planted crops and left to judge by itself when, which side and how much to turn distinguishing between the weed and crop on the basis of their height above the ground thereby extricating a lot of manpower which is otherwise needed for the task to be completed. Also, it's sensors' (used to distinguish between weed and crop) height can be adjusted thereby making it usable for different crops and different duration of work of weed removal during the cultivating period when the height of plants change as they grow.

ENGINEERING ANALYSIS & SPECIFICATIONS:

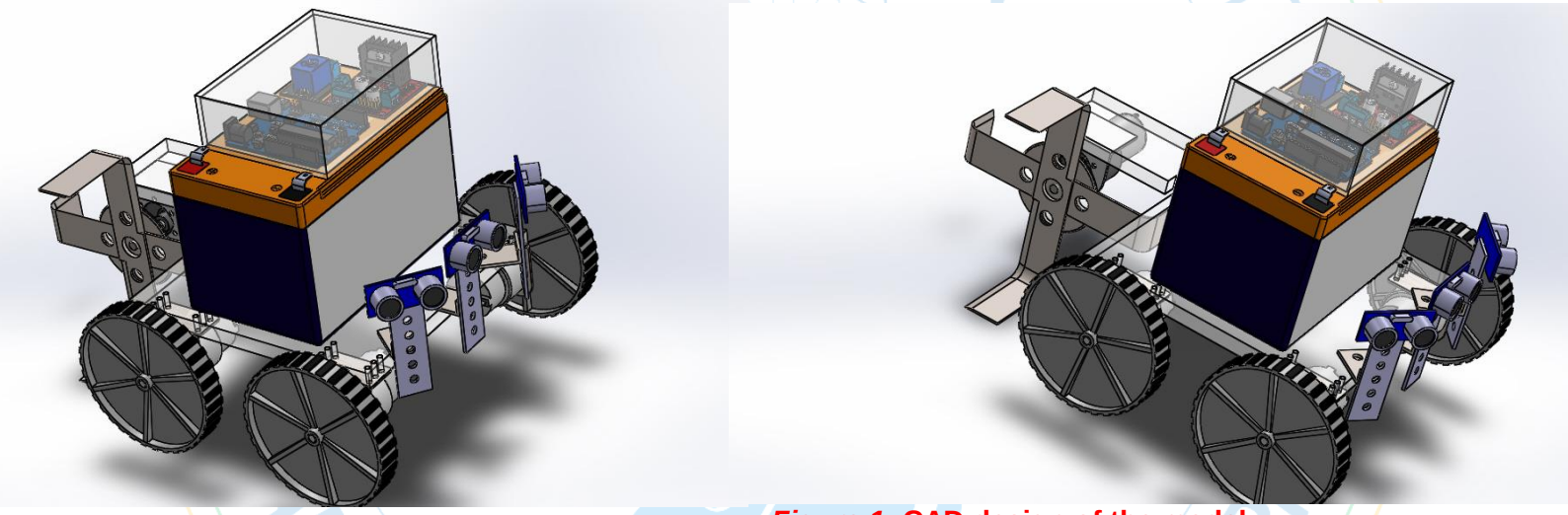


Figure 1: **CAD design of the model**

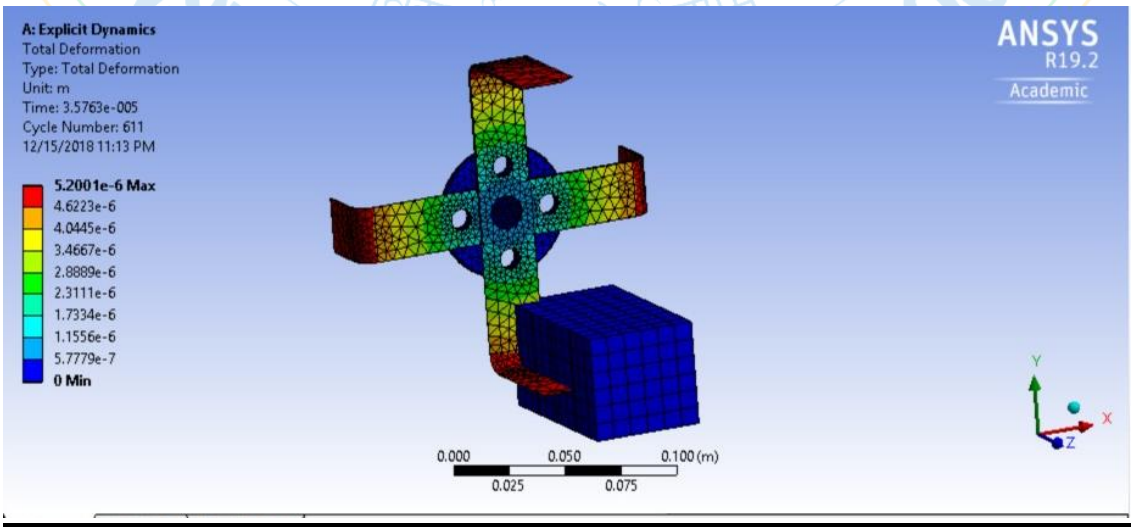


Figure 2: **Deformation Analysis of the tool**

Weight	5.6 kg
Wheel motor torque	20 Kg cm
Cutter motor torque	100 Kg cm
Cutter Depth (below tyres)	1.5 in
Dimensions	354.40 x 235.60 x 207 mm

- CAD models were prepared in SOLIDWORKS.
- Iterative approach were used to optimize mass and size after testing the prototype
- Cutting tool analysis was done on Ansys, to find its optimum *width & thickness and torque* required for the connected motor
- Cutter is made of Stainless Steel.
- Main frame is made of Acrylic

List of Electrical Components used in the robot:

S.no	Component	Specification	No. of pieces	Image
1	Ultrasonic sensor	HC-SR04 5V, 40KHz	3	
2	Motor driver		1	
3	Laser Module	650NM 5V, 5mW, 40 mA	1	
4	LDR detector module	KY-108 Photoresistor module	1	
5	Li-po Battery	11.1 volt, 3000mAh ORANGE 3000/3S-30C	1	
6.	Geared Motor	16 RPM, 120kg-cm torque, 12V DC	1	
7	Motors	200 RPM, 20Kg cm	4	
8	Arduino UNO		1	
9	Current Sensor	Up to 30A Current Sensor Module ACS712	1	
10	Buzzer	5V Electric Magnetic	1	
11	Relay Board	1 Channel 5V 10A, For Arduino PIC AVR DSP ARM	1	

Comparative Study between different types of Proximity Sensors:

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal.
There are many types, each suited to specific applications and environments. Types of proximity sensors - Inductive, Capacitive, Photoelectric, and Ultrasonic.

Characteristics	Capacitive	Capacitive	Ultrasonic	VL53L0X
Material sensed	Ferrous Metals	Liquid, metals, dry goods	All Materials	All Material
Sensing distance	0.5-120mm	0 -50 mm	0-50 mm	5-2000 mm
Sensitivity	Good	Good	Excellent	Very good
Cost	290 INR	210 INR	60 INR	930 INR
Reliability	Very good	False trigger concern	False trigger concern	Good
				

From the above comparison of the all the proximity sensors, it is clear that the ultrasonic sensor is cheap, durable, easy to use, but it occupies a lot of volumes and has false trigger concern. Therefore, we used three ultrasonic sensors to detect the main crop and the fences around the field. While the robot moves the ultrasonic sensor detects the distance of the main crop from the machine and if the distance of the main crop is less than a certain minimum distance, the robot will move and turn away from the crop. This will cause no harm to the main crop and only weeds are removed.

CIRCUIT SCHEMATIC:

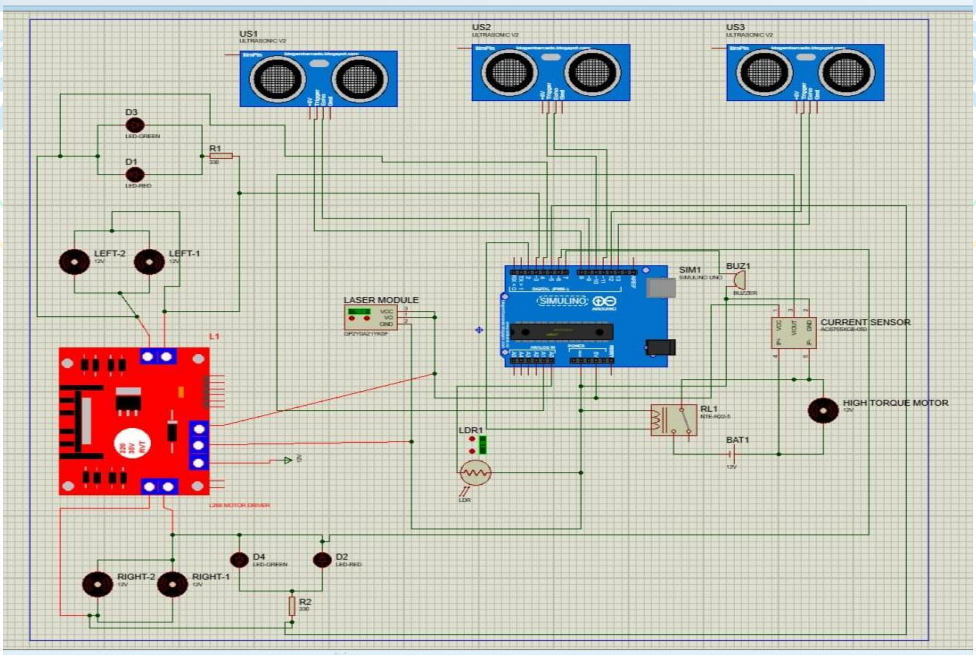
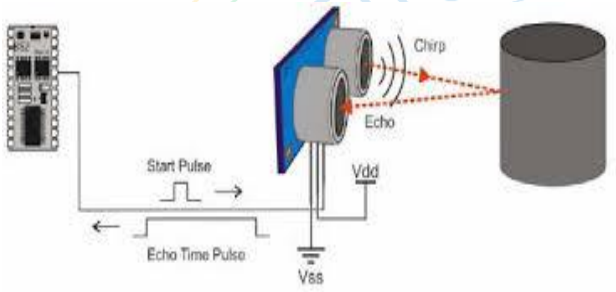
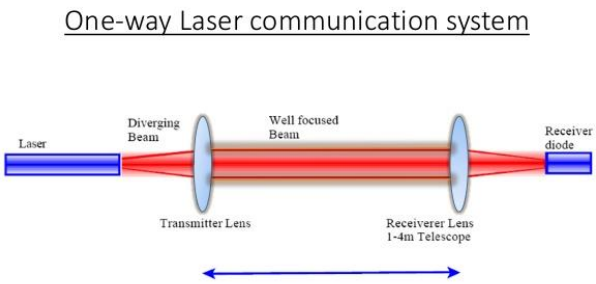


Figure 3: Circuit Diagram

WORKING:

The main principle of this weed remover is the difference in height between the main crop and the weed. The weeds are smaller while the main crop is taller. The three ultrasonic sensors (U1, U2, U3) are at an angle of 60, 90 and 120 degrees and measure the distance of the main crop in the field from the bot. In the process of manual cultivation of the farm, there is not very high accuracy in planting the crops in a straight line. Therefore, we used three ultrasonic sensors to prevent our bot from causing any harm to the crops. If the distance is less than certain minimum distance (i.e. 15 cm) from the ultrasonic sensor, the Arduino sends a pulse to the motor driver in terms of voltage to the motors. And the motor driver runs the motors present at the base of the chassis. This is how the bot moves and turns.





In order to detect the weeds, the robot contains a laser module that emits light waves of wavelength 950nm and a KY- 108 Photoresistor module which has an LDR (Light dependent resistor) that detects the intensity of light and varies its resistance. The variation of resistance of LDR is mapped (using the map function in Arduino) and when a weed comes between the laser emitter and the LDR module, the Arduino gets the variation in resistance of the LDR (due to change in the intensity of laser) and sends the signal to the relay. A relay acts as a switch in the circuit which powers the Johnson Motor. It is a high torque motor, that uproots the weed and hence kills them which will further act as manure to the field.

For the debugging of the code and detecting the direction in which the bot is moving, different LEDs are connected with the motors of the chassis.
The bot has an alarm system if in case the bot encounters an obstacle and fails to remove the weed. If the bot detects the weed and cutter fails to rotate due to an obstruction (stone) restricting the rotation of the shaft, then the current drawn by the motor will increase for constant voltage. This can damage the motor permanently. To avoid any such circumstances, a buzzer is connected with the Arduino which will turn HIGH when the current sensor connected across the motor terminals will detect any higher current. This will also send a signal to the relay to change its state and disconnect the motor from the 12V supply.

COST ANALYSIS:

ELECTRICAL PARTS

S.NO	PART	PART COST	QUANTITY	SUBTOTAL
1	ULTRASONIC SENSOR	80/-	3	240/-
2	LASER MODULE	75/-	1	75/-
3	LDR DETECTOR MODULE	80/-	1	80/-
4	LIPO BATTERY	2500/-	1	2500/-

5	ARDUINO	250/-	1	250/-
6	CURRENT SENSOR	150/-	1	150/-
7	BUZZER	20/-	1	20/-
8	RELAY SWITCH	79/-	1	79/-
9	MOTOR DRIVER	80/-	1	80/-
10	BATTERY CHARGER	2300/-	1	2300/-
11	COPPER CLAD BOARD	80/-	1	80/-
			TOTAL	**5854/-**

MECHANICAL PARTS

S.NO.	ACCESSORIES	PART COST	QUANTITY	SUBTOTAL
1	MACHINE SCREW	5/-	16	80/-
2	JOHNSON MOTORS	800/-	1	800/-
3	BASE MOTORS	120/-	4	480/-
4	MOTOR CLAMPS	20/-	4	80/-
5	MOTOR CLAMPS(JOHNSON)	15/-	1	15/-
6	WHEEL	20/-	4	80/-
7	CUTTER AND COMPONENTS	100/-	1	100/-
8	COUPLING	129	1	129
			TOTAL	**1635/-**
MISCELLANEOUS				
1	JUMPER	1/-	30	30/-
2	GLUESTICK	10/-	2	20/-
3	SOLDER WIRE			10/-
4	PLYWOOD			200/-
5	TAPE	10/-	2	20/-
			TOTAL	**280/-**

GRAND TOTAL: INR <u>7769/-</u>

<u>BUSINESS ANALYSIS:</u>

In India, agriculture is practiced on about 60% of its total land, that is 159.7 million hectares (394.6 million acres) which is second largest in the world. Numerous varieties of crops are grown along the stretches of the national boundary. Although weed removal is essential in almost all the crops but our machine focuses mainly on horticulture crops which include vegetables, fruits , flowers and spices.

- Our machine is effective in fields where crops are planted **row-wise on a levelled region**.

<u>VEGETABLES:</u>

Vegetables have about 59.3% share in horticulture production and 17.67% in total agricultural production.

Total area under cultivation: 10,290,000 hectares

Fields where our machine can be effective:

S.NO.	VEGETABLES	PRODUCTION	AREA
1	Beans	2278	230

2	Bottle gourd	2572	157
3	Brinjal	12400	669
4	Carrot	1379	86
5	Cucumber	1142	78
6	Chillies (Green)	3406	287
7	Lady Finger	6146	528
8	Peas	5452	546
9	Potato	46546	2164
10	Radish	2927	206
11	Pumpkin	1582	72
12	Sweet Potato	1639	135
13	Tomato	19697	809
TOTAL		**107166**	**5967**

FRUITS:

Fruits have a 31.5% share in horticulture production and 9.387% in total agricultural production.
Total area : 6,480,000 Hectares
Fruit Plantations where our machine can be effective are :
Almond (12,000 Ha), Gooseberry (91,000 Ha), Grapes (136,000 Ha), Papaya (136,000 Ha), Pomegranate (209,000 Ha)
Total area = 584,000 Hectares

SPICES:

These have a share of 2.4% in horticulture production and 0.7152% in total agricultural production.
Total area : 3,535,000 Hectares
Spices' fields where our machine can be effective are :
Garlic (274,000 Ha), Ginger (165,000 Ha), Turmeric (193,000 Ha), Pepper (131,000 Ha)
Total Area = 763,000 Hectares

FLOWERS AND AROMATIC:

These have a share of 1.1% share in horticulture and 0.3278% in total agricultural production.
Total area over which our machine is effective = 309,000 Hectares

OTHERS:

Some other crops where our machine can be useful :
Maize (9,000,000 Ha), Paddy (43,200,000 Ha), Cotton (6,205,000 Ha), Sugarcane (353,230,000 Ha)
Total Area = 411,635,000 Hectares

COST OF LABOUR FOR REMOVING WEED ONCE (PER HECTARE):

From our survey it came out to be around 5000 INR per bigha (tentatively minimum as Bihar renders cheapest workforce).
Now, 1 bigha= 37,000 sq. feet = 0.3437 Ha
Therefore, Cost of labour per Ha each time= 5000/0.3437 = 14,550 INR (approx.)

COST INCURRED FOR REMOVING WEED BY OUR MACHINE (PER HECTARE):

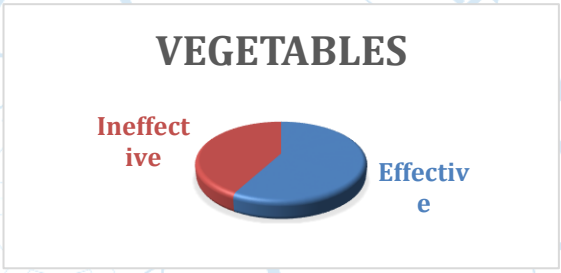
Our machine removes weed in area equal to a standard basketball court in 3.5 hrs.

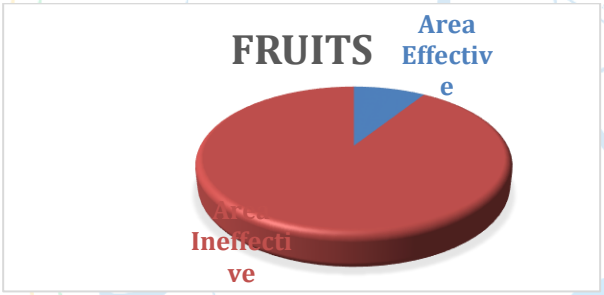
> Battery life = 3.5 hrs. -> One charge = 1 basketball court area
> 1 Bigha = 8 basketball courts (7.87 to be exact) -> 1 Hectare = 3 bighas (2.92 exact)

This infers about 8*3 = 24 charges required per hectare. Battery needs to be replaced after 250 charging cycles. This means about 10 hectares in a battery.
Cost of electricity (for 10 Ha) = (12 * 7.2 * 240 * 6.5) / (1000 * 0.8) INR = 168.48 INR
(12V operating voltage ; 7.2 Ahr battery ; Efficiency of battery 80% ; Cost per KWhr 6.5)
Maintenance Cost : Cost of battery 630 INR + Maintenance cost of other components 800 INR (10% of total cost) + Cost of Electricity 168.48 INR = 1598.8 INR
Therefore, **cost incurred by our machine per hectare** = 1598.8 /10 = **160 INR**

SAVINGS (PER HECATRE): 14550 -160 = **14390 INR** . **Saves 98.9 % cost.**

- **In vegetable fields weeding is required twice in a growing season, so savings are almost doubled.**





DISCUSSION WITH RELEVANT STAKEHOLDERS:

We visited some of the relevant stakeholders nearby us and presented before them our idea of the Autonomous Weed Remover. We interacted with some governmental and non-governmental organisations such as **Udyog Mitra ; BIA (Bihar Industries Udyog Association); Department of Agriculture, Government of Bihar** etc. and collected their feedback and reviews on our machine. We enquired to them about the feasibility, efficiency and cost effectiveness. They were impressed by our idea and approach as this problem is very common and our solution is economically feasible and this would reduce a lot of burden of the farmers. Apart from positive feedbacks they also suggested some enhancements we could ponder upon :

1) We could add a temperature sensor and an LED display. This would give the farmers idea of temperature variations so that they can act aptly to prevent failures of crop.
2) An improvement in chassis and suspension system would widen the target areas of our machine.
3) Proximity sensors can be included in the design which would detect presence of any intruder in the field such as cows, Nilgais (Blue Bulls) etc.

4) A GPS tracker can be added in our machine so that it doesn't go back to areas where the field has been already weeded.
5) Appropriate sensors which can measure the length of main crop will prove to be a boon for the farmers as this would give them information about the proper development of the crop and also warn them against any problem.