“DEVELOPMENT AND PERFORMANCE EVALUATION OF MANUALLY OPERATED SINGLE ROW MULTICROP PLANTER”.

Thesis
submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI - 413 722,
DIST. AHMEDNAGAR, MAHARASHTRA, INDIA

by

Nakate Shivprasad Madan

B. Tech. (Agril. Engg.)

In partial fulfillment of the requirements for the degree of

MASTER OF TECHNOLOGY

(AGRICULTURAL ENGINEERING)

in

Farm Machinery and Power

DEPARTMENT OF FARM MACHINERY AND POWER
DR. ANNASAHEB SHINDE COLLEGE OF AGRICULTURAL ENGINEERING,
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B. Tech. (Agril. Engg.)
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August, 2011

CANDIDATE'S DECLARATION

I hereby declare that this thesis entitled **"DEVELOPMENT AND PERFORMANCE EVALUATION OF MANUALLY OPERATED SINGLE ROW MULTICROP PLANTER"** or any part thereof has not been previously submitted by me or any other person to any other University or Institute for a degree or diploma.

Place: M.P.K.V., Rahuri. **Nakate Shivprasad Madan**

Date: / /2011 (Reg. No. 08/14)

Prof. A. B. Lende,
Research Guide and In charge Head,
Department of Farm Machinery and Power,
Faculty of Agricultural Engineering,
Mahatma Phule Krishi Vidyapeeth,
Rahuri- 413722.

CERTIFICATE

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The assistance and the help received during the course of this investigation have been acknowledged.

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Place: MPKV, Rahuri **(Nakate Shivprasad Madan)**

Date: / /2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

Abbreviation	Description
%	Per cent
Avg.	Average
B. Tech	Bachelor of Technology
CI	Cast iron
CIAE.	Central Institute of Agricultural Engineering
w.b.	Wet basis
Dr. ASCAE	Dr. Annasaheb Shinde College of Agricultural Engineering
Engg.	Engineering
Fig.	Figure
FMP	Farm Machinery and Power
h.	Hour
ha.	Hectare
I.D.	Inner diameter
i.e.	That is
Kg	Kilogram
m.	Metre
M.P.K.V.	Mahatma Phule Krishi Vidyapeeth
M.S.	Mild steel
m/s	Metre per second
min.	Minute
mm.	Millimetre
cm	centimeter
No.	Number
O.D.	Outer diameter
p.	Pages
RNAM	Regional Network of Agricultural Machinery
rpm.	Revolution per minute

Rs.	Rupees
sec.	Second
viz.	Namely
Km/h	Kilometer per hour
Wt.	Weight

ABSTRACT

DEVELOPMENT OF MANUALLY OPERATED SINGLE ROW MULTICROP PLANTER

By

Nakate Shivprasad Madan

(Reg. No. 08/14)

A candidate for the degree of

MASTER OF TECHNOLOGY

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in

Farm Machinery and Power

Dr Annasaheb Shinde College of Agricultural Engineering,

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August, 2011

Research Guide	:	Prof. A. B. Lende
Department	:	Farm Machinery and Power

The basic purpose of mechanization is to raise agricultural productivity, increase profitability and thus improve quality of life of farming community. There are around 74% farmers, who are small and marginal, having less than 2 ha land (Economic survey of India 2010-11). So, India's food security largely depends on these farmers. Hence it is need of time to make a technology according to their need.

Sowing of seed is an important practice in crop production. There are various methods of sowing the seeds, but precision planting is highly desirable. Precision planting is defined as the placement of single seed in the soil at desired plant spacing in a row. The spacing of the seed is affected when the mechanism fails to select or drop a seed resulting in large spacing between seeds. Keeping this in mind, the present study was undertaken to develop the manually operated single row multicrop planter.

In order to achieve this objective, the planter consisting of main frame, seed metering mechanism and power transmission unit was developed. The nylon plastic was used

for seeding unit. The seed rotor had the equidistant cells on its periphery. The row to row spacing was adjusted by varying the position of markers provided on both sides of the planter.

Tests indicated that weight of machine was 20 kg. Its average field efficiency was 69.44 % and the field capacity of 0.075 ha/h with Rs. 357 per hectare as an average cost of operation. Machine showed satisfactory results and it was suitable for small and marginal farmers.

1. INTRODUCTION

Today India's population is 120 crore (Census 2011).The total foodgrain production of India is 230 Million Tonnes (Economic Survey of India 2010-11). In 2046, the population of India will be 160 crore. It will be a food security challenge to Indian Agriculture. To fulfill the growing demand of foodgrain, Indian Agriculture has to increase its total food grain production exponentially.

There are around 74% farmers, who are small and marginal, having less than 2 ha land (Economic survey of India 2010-11). So, India's food security largely depends on these farmers. Hence it is need of time to make a technology according to their need. Agriculture sector provides employment to around 57% of total work force in the country. The share of agriculture in national income is about 16% (Economic survey of India 2010-11). In spite of the spectacular achievement, various constraints and disturbing trends have always continued to hamper the requisite growth of the agriculture sector, such as agriculture still gamble in monsoon., failure of land reforms and limited use of agricultural machinery.

The tools and implements used by the Indian farmers are primitive and crude as compared to developed countries. As a result of progressive mechanization of agriculture, these countries have been able to experience an agricultural revolution. Thus, the prosperity and richness of peasantry in developed countries has been due to extensive use of farm machinery. Naturally, there is no common belief that progressive agriculture is impossible without mechanization. The basic purpose of mechanization is to raise agricultural productivity, increase profitability and thus improve quality of life of farming community. While the case for mechanization of agriculture has some validity in the context of the need to raise agricultural production timely. In the first instance, there is extremely small size of holdings from 1 to 4 ha, which are scattered in tiny bits. It is true that full scale mechanization is not desirable for India, but machines suitable for small farms can be introduced.

In the crop production, the main practice for higher productivity is sowing the seeds. Sowing is the time bound operation. Early or delayed sowing will show adverse effect on crop yield. It depends on single seed being placed at equal intervals in a row. To overcome this problem, planters were introduced. There are various methods of sowing the seeds such as random scattering of seeds i.e. broadcasting, drill seeding, hill dropping and precision planting. The precision planting is highly desirable. Precision planting is defined as the placement of single seed in the soil at desired plant spacing in a row. Usually farmers use the hand dibbler to achieve this accuracy. The sowing device equipped with single seed metering device is called as precision planter. The horizontal plate planters having cells on periphery were the first planters developed. Although the horizontal seed metering is popular, problem occurred such as higher seed damage & missing and multiple drops. To minimize these losses inclined and vertical plate planters were introduced.

The spacing of the seed is affected when the mechanism fails to select or drop a seed resulting in large spacing between seeds. To achieve accurate seed spacing, different parameters that affect placement of seeds such as, travel speed, peripheral velocity and shape of holes in the plate and singulation of seeds are considered. Any seed planter has to perform the following operations:

1. To hold and carry the seeds along the field.
2. To open the furrow at a pre-determined depth.
3. To meter or distribute the seeds at a required spacing and
4. To close the furrow after placing the seed.

With due consideration to the above facts, the use of large power tractors and power tillers are uneconomical and unaffordable for small and marginal farmers. Thus, manually operated equipment may prove to be a better solution. Being compact and tidy with ease in operation, better field maneuverability, saving in time and labour, will prove the planter to be very beneficial to the small and marginal farmers. Hence, keeping these vital aspects in mind the present study was undertaken in the Department of Farm Machinery and Power, Dr. A. S. College of Agricultural Engineering, MPKV, Rahuri, with the following objectives:

1. To develop a manually operated single row multicrop planter.
2. To conduct functional tests of a manually operated single row multicrop planter.

2. REVIEW OF LITERATURE

In view of the objectives set for present study, the work of earlier researchers was reviewed for getting thorough idea of the development work on seeding machines, the problems encountered and the remedies to overcome the problems while achieving the objectives set for the present study. The review made for this work is presented through the following heads:

1. Development of seed drills and planters.
2. Development of seed metering mechanism.

2.1 Development of Seed Drills and Planters

Mysto limited (1929) consisted of a brass seed container of barrel shape with a push-on lid and having at the lower end a brush feed that was operated by an outside driving wheel fitted with a rubber tyre. An adjustable slide controlled the feed and the seed was finally delivered.

An important feature of the **'Hemsky R-8'** force feed drill (1937) was that of each seed housing was provided with a simple device for disengaging the fluted roller, thereby stopping the seed flow on any desired row.

Wright (1941) studied seed corn grading in relation to planting. He reported that corn had length, breadth and thickness, also each of these dimensions were related to accuracy of the planter and to design planter plate, it was necessary to separate the seed according to all the three dimensions.

Bajerkan (1947) observed certain irregularities in the rate of planting and found the causes responsible as more slippage would occur in rough and cloddy fields than on smooth and well packed ground and if seeds were larger in relation to seed-cells, one could expect larger variation in planting rates resulting from change in speed, where the seed varied in size, there was tendency to plant smaller seeds first with the result that the planting rate tapered off as the seed size. He suggested remedies to tackle the problems as the seed should be graded to a uniform size, the matching of seed plates, the sizing of the seed should be checked prior to planting, if the portion of the seed which was too large for the plate being used, the hopper should be emptied periodically.

Autry and Schroeder (1953) studied the factors affecting the design of hill drop planters. They observed that higher accuracy could be obtained by use of compact cells. The speed of 30 rpm resulted in highest accuracy and higher mean cell hill. Accuracy was affected less by changes in the number of cells per plate. Ground scattering was affected by height of fall, but it might be reduced by use of hopper height of 45 cms or less.

Anonymous (1957) tried to modify the seed metering device for groundnut and gram. The modification was done in the shape of slots for seed on the rotor. The rotor was designed considering different parameters with respect to width, length and depth of slot and size of seed.

Richey *et al.* (1961) discussed the working on shoe type furrow opener, which opened the soil to deposit the seed. It cut the soil for receiving the seed with the least disturbance and the draft. The slug helped the moist soil to cover the seed.

Griffiths (1964) developed a seed-sowing machine that comprised a disk having a layer of soft and resilient material such as foam polyurethene, which was pressed against the opening of a hopper, and they were discharged down through a funnel to a delivery conduit. Opening was adjusted by providing interchangeable gates having different size apertures.

Nolle (1964) seed sower comprised a hopper and an agitator by means of a rod connected to a crank pin or a wheel. The material was fed through a rectangular aperture in the bottom of hopper, which could be adjusted.

Dodwell (1964) developed a pneumatic seed-sowing device which comprised a hopper that rotated with an endless belt with holes. Seed was picked by the belt opening and discharged down. The compressed air was used to discharge the seeds from openings.

In **Fisheri (1965)** seed-sowing machine, the seed was fed from a hopper by means of an adjustable metering device to a housing provided in a layer of soft material. The seed was picked up by cups mounted on a pair of chains, each cup being provided with plunger, which was operated by each lever when it contracted or stopped to eject the seed.

A tractor mounted seed sowing machine designed by **Murphy (1965)** had a trough provided with blocks and a shaft passing through the upper portion of blocks and carrying the toothed wheels, which fed the material to openings in the trough. The shaft might be driven from a wheel of tractor or from P.T.O.

Wanjari and Sawant (1968) studied the effect of certain variables on metering uniformity and seed spacing. The uniformity of metering was checked for each plate at three speeds. The speed had little effect on average metering rate for any of the plates. Metering variation occurred among seed hopper on the same planter. These fluctuations occurred due to hopper bottom followed by plate speed and plates. The seed tube of three quarter inch and angled 30° backward gave shortest average skip length in the seed planter.

Sandge (1979) developed Jyoti seed drill and planter for the crops like wheat, cotton, gram, jowar, etc. It was found that one pair of bullocks could provide the draft required for the planter. It was found to be more effective in applying the fertilizer at proper depth and distance from the seed.

A seed metering mechanism of usual design which claimed to offer simplicity, infinitely variable seed drop rates and few moving parts had been designed by **Davis (1980)**. This won the "Lincolin Power Farming National Farm Inventors" award. Seed from hopper dropped onto rotating rollers around three of its sides so that the seed might exit from only the remaining open side. The meter gear attached to the roller shafts actuated the roller.

Benedict Ltd. (1981), employed mono seeder unit attached to a carrying box and the seed placement was by a selector wheel with an ejector plate in the 'Tume' precision drill. Seedling emergence from this relatively simple machine averaged out at 82 per cent.

Bamlett (1981) developed Tyne drill which pneumatically placed seeds uniformly both in spacing and depth, so that each seed was in the optimum position for the best start. The germination was more with less wastage and the crops gave better yield and quality.

Harrian (1981) designed the six row version of multi row drill, a radical departure from conventional design which used a centrally mounted hopper and pneumaticised the seed to the individual seeder unit. The assessment trials indicated that this concept worked the best at higher drilling speeds.

Sharma (1983) developed a bullock drawn seed-cum-fertilizer drill, in which the drive for the metering shaft was taken from the ground wheel through a V-belt pulley. The separate fluted roller assemblies were provided to ensure uniform dropping of both seed and fertilizer.

Baloch and Mughal (1985) modified the existing traditional bullock drawn planter. This consisted of a wooden rotor mounted in between the bowl and tube. A groove approximately equal to the size of maize grain was present on the periphery of the rotor. The modified implement was then tested and found useful as compared to conventional one.

Nadget Gougis (1987) developed SL 600 model drill in which air was supplied to primary coulter tube through a manifold and P.T.O. driven fan mounted at the side of hopper. The seed was metered to gear driven fluted rollers into a venturi in each tube and carried by the air stream to two-way splitters. It then passed to coulter shoes, where the air was swirled out by a cyclone seperater, allowing the seed to drop into furrow under gravity.

Bansal (1987) developed a furrow planter and fertilizer applicator mounted on a frame supported on two steel wheels. Metering mechanisms were driven from the left wheel of planter. A dog clutch disengaged the drive to the metering mechanism as soon as the furrow openers were lifted. Floating type soil deflectors followed by a press wheel ensured proper soil covering.

Fashima (1987) developed a manual seed planter having three metering plates, which had different numbers of cups, welded onto it. The movement from the front wheel was transferred to the seed plate through sprockets. The seed in each cup was released through a hole to the seed tube.

Paul (1988) developed a Jab Planter, in which the planting stick was PVC tube which acted as hopper. Metering slide was operated by a simple trigger passed through the bottom of hopper. The seed removed from hopper was caught by funnel and delivered to the point.

Kadu (1996) reported that new planting equipment viz., Jyoti multicrop planter was suitable for sowing soybean, groundnut, sunflower, safflower, gram, tur, maize, wheat and jowar. In general high planting production efficiency was observed.

Khetmalas and Varma (2003) carried out the refinement of bullock drawn Jyoti multicrop planter according to the feedback from the farmers, to make the planter light weight. Wooden fertilizer box was replaced with GI box and cast iron gears were replaced with aluminum gears. Also they reduced the capacity of fertilizer box. They reduced the weight of bullock drawn Jyoti multicrop planter to 60 kg from 85 kg.

2.2 Development of seed metering mechanism

Harvath (1958) had developed a pneumatic precision seed drill whose principal component was hollow drum with a series of holes in its periphery rotating on a tubular shaft through which air could be exhausted. Drum was half immersed in seed hopper so that single seed was held by suction. As the drum revolved, by a scraper caused the seeds to drop off. Drive was given by shaft and gearing from land wheel. One of the advantages claimed was the saving in seed.

False (1960) developed positive drive achieved from both the ground wheels, driving through gearing. A large cell wheel was employed a wide arc of which was in contact with the seed to ensure filling. A scraper roller kept the seed moving and allowed only one seed into each cell. Various cell wheels were available for sowing all types of seeds from carrot to beans.

Hestaur Farm Equipment Ltd. (1981) developed a one piece toothed metering roller, which handled all sizes of seeds . The metering rollers made of polyurethane and had a staggered tooth pattern across the whole of the width to give a consistent feed pattern. For handling small seeds, rollers incorporated a narrow central band, which operated in conjunction with adopter plate.

Anonymous (1997) stated that chain and sprocket mechanism for seed metering, deliver high power while using less moving parts, since toothed sprocket allow for higher reduction ratio and slip proof drive. It was more economical, resistance to many hostile conditions including temperature, moisture, and dust.

Kocher *et al*. (1998) developed an opto-electronic seed spacing measurement system that measured time intervals between the seeds, and detected front and back seed drop location events to determine the seed spacing uniformity of a planter in the laboratory. They used a seed detection sensor consisting of a rectangular photo-gate with 24 photo transistors receiving light beams from light-emitting diodes. The space measurement obtained based on time intervals between seeds drop events were strongly correlated with the space measurements obtained on a greased belt test stand. The accuracy, however, depended upon the size of the seeds and photo-gate.

Zeliha Bereket *et al.*(2003) determined the effect of different operating parameters on seed holding in a single seed metering unit. The metering unit was a vertical seed plate with a vacuum, used to seeding maize (Zea mays L.). An electronic counter in the metering unit was used to determine the holes without seed on the plate.

The shapes of the holes, peripheral velocities, vacuum pressure, hole area on the seed plate and thousand grain weight of seed were chosen as the operating parameters. They found that the hole shape, peripheral velocity, vacuum pressure, the hole area and thousand grain weight of seed had an effect on the seed holding ratio at a significance level of 1% . The most suitable shape of the holes in the seed plate was oblong for maize seeds. The seed holding ratio decreased when the peripheral velocity of the seed plate increased, whereas the seed holding ratio increased

parallel to the increase in vacuum pressure. An increase in the thousand grain weight of seed necessitated a larger hole area for holding seeds on the plate holes.

Reheman and Singh (2004) developed a sensor for seed flow from seed metering mechanism. A sensor based on a light interference technique had been developed for sensing the seed flow from the metering mechanism of planter. The developed sensor successfully censored the seed dropping for mustard and wheat seeds with a maximum error of 18 per cent. These errors were due to inability of the sensors to detect multiple seeds in a small amount of time. Error within 10 per cent was found for maize seeds because of more time gap between two consecutive seed droppings. Despite these errors, this would definitely give the operator a simple indication by which he could know the workability of the metering device.

Karayel *et al.*, (2006) studied the fluted wheel metering mechanism. They used high speed camera to study uniformity of seed spacing and falling velocity of seeds. They compared their result with sticky belt stand results. They found that the sowing uniformity of seed drill was affected by speed of the rollers. The coefficient of variation of seed spacing and velocity of seed fall was inversely proportional to the speed of metering rollers.

Shinde (2008) developed an electronic metering mechanism for Jyoti multicrop planter for sowing groundnut. For this, ATMEL 89 (5) microcontroller and opto-isolator sensor was used. The circular seed plate rotated between opto-isolator sensors. The opto-isolator senses each hole on the periphery of the rotating disc and issued a pulse output. The distance covered by the planter was then measured in terms of the number of pulses being output in a span of time. Each furrow opener of the implement was provided with check valve activated by solenoid. The electronic metering mechanism was controlled through keyboard and two additional switches.

3. MATERIALS AND METHODS

Based on literature cited, it was evident that sowing was the most important farming operation that decides production. After reviewing the research studies of the previous works following parameters were considered for development manually operated single row multicrop planter.

1) It should plant almost all types and varieties of crops.
2) It should consist of proper metering device to maintain the desired crop geometry.
3) There should be provision of row spacing adjustments.
4) The weight of the machine should be within the pushing power of the human kind.
5) The material used for various components should be of proper strength, durability and should perform intended functions with ease.
6) It should be simple in design.
7) The setting of delivery tube should be straight to avoid clogging of seeds.
8) Easy to repair with minimum maintenance.
9) Low cost of operation per hectare.
10) Height of seed box minimum from ground to avoid bouncing of seed.

Keeping in view all the above points, this chapter deals with description of different systems of the planter and its testing procedure through the following sections.

1) Functional units of manually operated single row multicrop planter.
2) Working mechanism
3) Test procedure
4) Instrumentation.

3.1 Functional units of the multicrop planter:

The functional unit consisted of the following sub-units:

1) Main frame
2) Power transmission unit
3) Seed unit
4) Seed box

3.1.1 Main frame

The main frame assembly was made of Φ29 size mm m.s. pipe. It could support seed box and tyne. The seed box was mounted on main frame with support. Total length of main frame was 1119 mm. The main frame assembly is shown in Fig.3.3.

3.1.2 Power transmission unit

The power transmission unit consisted of the following components:

1.Ground wheel.

2.Power transmission shaft.

3.Chain and sprockets arrangement.

3.1.2.1 Ground wheel

The ground wheel was provided on the front side of the frame which formed the functional component of power transmission unit (Fig. 3.4). The rotation of ground wheel caused the rotation of vertical rotor through chain and sprocket arrangement. Simple bicycle wheel was used as ground wheel. The effective diameter of ground wheel was 50 cm. The ground wheel rotateds with the shaft on which it was mounted.

3.1.2.2 Power transmission shaft

The power transmission shaft was supported in two bush bearing fitted to the main frame. It rotated inside bush bearings provided at the ends with rotation of ground wheel. The shaft was made of m.s. bright bar of 16 mm diameter and 28.69 cm in length. A sprocket having 18 number of teeth was mounted on this shaft to transmit power from ground wheel to rotor shaft.The power transmission shaft is shown in Fig.3.7.

3.1.2.3 Chain and sprockets arrangement

The power transmission shaft is shown in Fig3.8 The seed rotor was mounted on the shaft. The shaft had square section at its middle to enable the seed rotor having central hole of same size and shape, to be mounted on the shaft. The shaft received power from ground wheel through the chain and sprockets arrangement. The driving sprocket was mounted on the ground wheel and the driven was on the power transmission shaft. Both the sprockets had the same size and same number of teeth viz.18. The pitch diameter of the sprocket was 12.7 mm. Suitable chain was used to connect the two sprockets.

3.2 Seed unit:

It comprised the following mechanism components:

1.Seed box.

2.Seed metering mechanism.

3.Furrow openers.

4.Seed covering device.

3.2.1 Seed box

The planter was provided with a seed box as shown in Fig3.5. The seed hopper was trapezoidal in shape. The size of the seed hopper was 179 x157 at the top and was 160 x138 mm at the bottom and depth of the seed hopper was 204 mm. The seed hopper was made of G.I. sheet of 1.6 mm thickness. The total carrying capacity of seed hopper was 2 kg seed of maize. At the bottom of the hopper, a rectangular slot of size 73 x 31 mm was provided to which the plastic body rotor was inserted. The seed box was supported on a support 250 mm above the bottom of the main frame. The hopper was kept close to the ground level to reduce the time of travel of seed from metering unit to the furrow to a minimum and to drop seeds at low terminal velocity.

3.2.2 Seed metering mechanism

The mechanism used for metering of seed was of vertical rotor type with seven number of cells for seed. The cells on the vertical rotor were located at the periphery of the rotor. The seed was picked up in each cell from the hopper and then dropped into the seed tube. Separate rotors with different cell sizes could be used for different crops. The seed metering mechanism was comprised the following components:

1. Seed rotor.
2. Seed rotor cover box.
3. Seed rotor shaft.

3.2.2.1 Seed rotor

A plastic moulded rotor of 96.5 mm diameter and 14 mm thickness was used for metering the seed. The cells were provided on the periphery of the vertical rotor, as per the spacing requirement of the crop to be sown. This rotor rotated in the seed rotor box with the help of shaft. The rotor had the 'square d' shape hole for mounting on shaft, which was having 'square' shape at the mid length, so that there was no need to have a key and key way arrangement for the rotor and shaft. While changing the rotor for other crops, the shaft was to be removed first and then the rotor body was split out and another rotor was to be placed in the body. Separate rotors were to be used for planting different crops. The cells in the rotor were made according to the seed size and the number of cells on the rotor depended on the recommended plant to plant spacing. The numbers of cells to be kept for a particular crop were computed by using formula:

$$N = \frac{S}{V \times Hd}$$

where,

N = Number of cells on the rotor.

S = Circumference of the ground wheel in cm (i.e. 157 cm).

V = Velocity ratio or number of revolutions made by rotor in one revolution of ground wheel (i.e. 1:1)

Hd = hill to hill or plant to plant spacing in cm.

Based on the above formula, the plastic seed rotors were manufactured with the required number of cells to obtain the recommended seed rate per hectare and also plant to plant spacing.

Table 3.1 Number of cells on rotors for different crops.

The required number of cells for different crops is given in the table below, depending upon the plant to plant spacing requirement of the different crops.

Sr.No.	Crop	Recommended plant to plant spacing,cm	Number of cells on periphery of rotor
1	Soybean	5-10	15
2	Maize	20-25	7
3	Gram	10	15
4	Pigeon pea	15	10
5	Jowar	15-20	10
6	Wheat	Line sowing	--

3.2.2.2 Seed rotor cover box

The seed rotor was fitted inside the rotor body shown in Fig 3.5.This body could be split in two parts by means of a hinge arrangement, so that the rotor could be removed and replaced by another one very easily. The upper half portion of body was fitted to the seed box with nut and bolt where a rectangular slot was provided. The lower half portion of body was hinged at one end and having nut and bolt arrangement at the other end so that the lower half portion of body could be easily split to replace the seed rotor. Each half portion of body was having a semicircular collar in which the hub of seed rotor matches and rotates within. The joint of these semicircular collars acted as a bush for the rotor hub through which the shaft was passed. The lower portion of body was funnel shaped having a circular discharge chute of size 25 mm diameter. The seed tube was mounted on this discharge chute for carrying the seed to the boot of furrow opener.

3.2.2.3 Seed Rotor shaft

The rotor shaft of 16 x 16 mm was made of m.s. bright bar (Fig.3.7). The length of the shaft was 286.9 mm and was having a square section at the middle of the length. The remaining two sides were made of round section of 15 mm diameter so that the shaft could be supported in two bush bearings of 15 mm size having 25.4 mm length each.

3.2.3 Furrow openers:

A furrow opener was fitted on the main frame of the planter with clamp arrangement. The furrow openers could be moved vertically at any desired level on the main frame, by loosening the nut and bolt arrangement. The standard of furrow opener was made of M.S. flat of size 413 x 32 x 25 mm and welded with the opener of high carbon steel. The lower end of the standard was hot forged and having bend, on which the opener was welded, forming an obtuse angle with the soil. The sweep was provided at the bottom of standard with overall dimensions of sweep as 99 x 57 x 25 mm with a sharp-pointed triangle at the leading edge. A plastic pipe of 28 mm diameter, 2 mm thickness and 100 mm length was clamped at the rear of furrow opener for dropping the seed through it. The furrow opener is shown in Fig 3.9.

3.2.4 Seed covering device:

The horizontal plate of M.S. was provided at the rear of the seed dropping outlet. It covered the seed with soil after dropped through pipe.

3.3 Working of the metering mechanism:

When the equipment was operated in the field, the ground wheel being in contact with the soil, rotated at uniform speed. The rotations of the ground wheel were transmitted through the power transmission unit to the seed rotor shaft. The shaft of the ground wheel rotated the sprockets mounted on its shaft. The power of the ground wheel was transmitted the sprocket on its shaft and the chain to the sprocket mounted on the seed rotor shaft. Both the sprockets being of same diameter and having same number of teeth, rotated at the same speed. Thus, the speed rotor was making same number of revolutions per minute as those of the ground wheel. In one rotation of the ground wheel, the planter covered a distance of 157 cm . During this time, the seed rotor also made one rotation and there being seven seed cells on the seed rotor, it dropped seven seeds/hills. Thus the plant to plant distance of approximately 22.5 cm was obtained, which matched with the Agronomic Recommendation of 20 to 25 cm for maize.

3.4 Test procedure:

Testing of the planter was done as per the guidelines of the procedure suggested by the Regional Network for Agricultural Machinery (RNAM, 1985) and BWAS test code WAS: 6316-1993 and WAS: 6813-1993. As per the procedure, there are following tests to be conducted on any farm machine / implement:

1. General test.
2. Laboratory test.
3. Field test.

3.4.1 General test

3.4.1.1 Checking of specifications

After development of the multicrop planter, all the specifications were checked for their accuracy.

3.4.1.2 Checking of material

The material of each and every component of the planter was checked and found to be as per the specifications.

3.4.1.3 Visual observations and provision for adjustment

The planter was visually observed and necessary adjustments were made.

3.4.2 Laboratory tests

3.4.2.1 Seed metering test

It was used to determine the seed dropping rates obtainable at different settings and when the planter was stationary.

3.4.2.1.1Calibration procedure

1. The planter was set on flat and leveled surface. Bricks were placed under the frame so that the ground wheels could be rotated freely.

2. The plastic bowls were placed at lower end of the furrow openers for collecting seed.

3. Ground wheel was marked at one point with chalk and it was rotated for 10 revolutions. The area covered by the planter was calculated theoretically. The quantity of seed collected in the plastic bowls was measured for each furrow opener.

3.4.2.2 Seed damage determination test

It was used to determine any mechanical damage done to the seeds during calibration. The seeds from furrow opener were collected after passing through the metering device and sorted out into two lots *viz.*, undamaged seeds and damaged seeds. The percentage of damaged seeds was calculated by following formula:

$$\text{Damaged seeds percentage} = \frac{\text{Damaged seeds}}{\text{Total seeds for hopper Filling}} \times 100$$

3.4.3 Field test

The testing of the developed equipment for maize planting was conducted at the ‘D’ block of Central Campus Farms MPKV, Rahuri. This trial was conducted in field of 0.45 ha without any replication. During the test, various parameters related to soil, crop and machine were studied and the data was recorded. They were presented as under:

3.4.3.1. Soil moisture content

The soil moisture content was measured by the oven method at randomly selected five places in the field.

3.4.3.2. Shape and size of field

Dimensions of the field were measured with help of flexible tape of 30 m length.

3.4.3.3 Depth of seed placement

Depth was measured using meter rule. For this five random observations were taken and average was calculated.

3.4.3.4 Seed rate

Seed rate was calculated by total weight of the seeds used for plantation of the selected field plot.

3.4.3.5 Theoretical field capacity

The theoretical field capacity was calculated by following formula:

$$\text{Theoretical field capacity (ha-h-1)} = \frac{\text{Width, m x Speed, kmph}}{10} \times 100$$

3.4.3.6. Actual average travelling speed

Two wooden pegs were inserted in the field, 20 m apart. The time required to pass the distance between two pegs by the equipment was noted. The speed was calculated as km h-1.

3.4.3.7. Actual operating hours

It was the total time required to complete whole operation. It was recorded by stop watch.

3.4.3.8. Effective field capacity

It was calculated by following formula.

$$\text{Effective field capacity, ha-h-1} = \frac{\text{Actual area, ha}}{\text{Time required, h}}$$

3.4.3.9. Field efficiency

Field efficiency was calculated by following formula.

$$\text{Field efficiency, \%} = \frac{\text{Effective field capacity, ha-h-1}}{\text{Theoretical field capacity, ha-h-1}} \times 100$$

3.4.3.10. Man-hours requirement

The man power required for the complete operation was observed and recorded.

3.4.3.11. Plant population per hectare

It was measured by taking observations at five randomly selected spots by using a 1 m^2 size square metal frame and by counting number of plants inside the frame.

3.4.3.12. Per cent germination

The germination percentage was calculated by using the following formula:

$$\text{Germination, \%} = \frac{\text{Number of plants germinated}}{\text{Number of seed sown}} \times 100$$

3.5 Instrumentation

Different parameters *viz.*, speed, time, weight, moisture content, dimensions were measured while conducting the laboratory and field tests. The following instruments were used:

3.5.1 Stop watch

Stop watch having least count of 1 second and maximum time recording capacity of 30 minute was used for recording the time parameter during tests.

3.5.2 Vernier calipers, steel tape, metallic tape and steel rule

These measuring instruments were used to measure the dimensions of the machine components and field dimensions *viz.*, operating width, working depth, etc.

3.5.3 Weighing platform and balance

The weighing platform of 500 kg capacity was used to measure the weight of the machine and the weighing balance of 5 kg capacity was used to measure the weight of the seed and fertilizer while conducting the calibration test.

3.5.4 Electronic moisture meter

It was used to measure moisture of soil at the time of planting.

3.5.5 Metallic frame

A metallic frame of 1 x 1 m size was used to measure the plant count and percent emergence.

4. RESULTS AND DISCUSSION

This chapter deals with the results of performance evaluation of manually operated planter. Tests were conducted in both, laboratory and field. The laboratory tests were conducted in Workshop Technology Laboratory (College Workshop), while the field tests were conducted at ‘D’ block, Central Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri. The seed of “Rajarshi” variety of maize selected for the tests. The results of tests are discussed below:

4.1 Laboratory Test

The following laboratory tests were conducted on the newly developed machine in the Workshop Technology Laboratory (College Workshop):

4.1.1 Calibration test

The manually operated planter was calibrated for determining the seed rate of the machine. Standard calibration procedure was followed as discussed in Materials and Methods chapter. Before doing the calibration of the planter for seed, the metering mechanism was set for 22.5 cm plant to plant spacing and metering plate having 7 cells on its periphery was used. The seed of “Rajarshi” variety of maize was used for calibration purpose. The test data of the machine are given in Table 4.1 and 4.2 for seed distribution.

For calibration of the machine, total three replications were taken, in which weights of seed collected from furrow opener varied from 0.0171 kg to 0.0185 kg (Table 4.2). There was no remarkable variation of seed rate for three replications. The average seed rate in three replications was found to be 19 kg/ha, which was at par with recommended seed rate of 15-20 kg/ha for the maize verities (Anonymous,2011).

Table 4.1 Calibration test data of manually operated single row multicrop planter.

1.	Date	15.07.2011
2.	Place	Workshop Technology Laboratory
3.	Row spacing	0.6 m
4.	Length of strip to cover one hectare area	16666.6 m
5.	Diameter of ground wheel	0.5 m
6.	Number of revolutions of ground wheel to cover the length obtained in (4)	10610
7.	Number of revolutions of ground wheel to cover 1/1000 ha	10.61
8	Area covered in 10 revolutions	9.42 m^2
9	Revolutions per minute of ground wheel at speed of 1.80 km/h	19.10 rpm.
10	a. Kind of seed	Maize
	b. Variety of seed	Rajarshi
	c. Weight of 1000 seed	227 gm

Table 4.2. Calibration of planter by giving 10 revolutions to the ground wheel for maize

Replication No.	Weight of seed collected at furrow opener (kg)	Average seed collected (kg)	Average seed rate (kg/ha)
1	0.0171	0.0179	19
2	0.0185		
3	0.0181		

4.1.2 Seed damage determination test

The seeds from furrow opener were collected after passing through the metering device and sorted out into two lots viz., good seeds and damaged seeds. The weight of the damaged seeds from furrow opener was taken and the percentage of damaged seeds after the test was calculated and tabulated in Table 4.3.

Table 4.3. Damage caused to the seeds during calibration

Test No.	Per cent damaged seed before passing seed metering device	Damaged seed after the seed metering, (%)	Average damaged seed (%)
I	0	2.90	2.90
II	0	3.01	
III	0	2.81	

It was observed from the table 4.3 that seed damage percentage varied from 2.81 to 3.01 per cent and average seed damage was found to be 2.90 per cent, i.e. approximately 3 per cent.

4.1.3 Seed germination test

The germination test procedure was followed as discussed earlier in Materials and Methods chapter. The percentage of germination of seeds after the test was calculated and tabulated as in Table 4.4.

Table 4.4. Seed germination per cent determination test.

Germination paper no.	No. of seed placed	No. of seeds germinated	Germination, %	Average germination, %
1	50	43	86	86.4
2	50	45	90	
3	50	43	86	
4	50	44	88	
5	50	41	82	

It was observed from the table 4.4 that that seed germination percentage varied from 82 to 90 per cent and the average seed germination percentage was found to be 86.4 per cent, i.e. approximately 87 per cent.

4.2 Field Tests

The planter was tested in the field for evaluating the field performance. Field test was conducted by using seeds of maize (variety "Rajarshi"). All the settings and adjustments were done before performing the test. The observations were recorded during the field test and the results are discussed through following sections:

The planter was tested for its performance under the conditions given in table 4.5. The performance test data was analyzed and the final test results are tabulated in table 4.6.

Table 4.5 Test conditions for performance evaluation of manually operated single row multicrop planter.

Sr. No.	Particular	Values
1.	General	
	Date of test	15.07.2011
	Location of test	'D' block, Central Farm, MPKV, Rahuri.
2.	Field parameters	
	Type of soil	Medium black
	Soil moisture content, % (w.b.)	18.53
	Plot size, m^2	25 x 18
3.	Machine parameter	
	Name of implement	Manually operated single row multicrop planter
4.	Seed parameters	
	Name of seed	Maize
	Variety of seed	Rajarshi
	Germination percentage (min.)	75
	Max. moisture, % (wt.)	12
	Av. weight of 1000 grain, gm	227
5.	Labour requirement	One

4.2.1 Area covered and duration of test

The total area covered during the functional field tests was 0.1 hectare and the duration of the test was 1.33 hour.

4.2.2 Soil and soil moisture content

The test was conducted in medium black soil. The soil samples collected during the test were analyzed to measure the moisture content. The average soil moisture content of the field plot was found to be 18.53 per cent on dry basis.

4.2.3 Depth of placement

The depth of seed placement varied from 4.2 to 4.6. The average depth of seed placement was observed to be 4.36 cm.

4.2.4 Seed rate

The average seed rate was found to be 19 kg/ha for maize.

4.2.5 Emergence, plant count and plant geometry

The emergence, plant count and plant geometry was measured after 15 days of planting. The average plant count of 9 plants per square meter was obtained. The average emergence was observed to be 80 per cent. The average plant geometry obtained was 60 x 22.5 cm.

4.2.6 Plant population

The average plant population was observed to be 74074 plants per hectare.

4.2.7 Speed of operation

The average speed of operation was about 1.80 km/h.

4.2.8 Effective field capacity

Average effective field capacity of the planter was found to be 0.075 ha/h for maize.

4.2.9 Field efficiency

The average field efficiency obtained for planter was 69.44 per cent.

Table 4.6 Results of the performance evaluation of manually operated single row multicrop planter.

Sr no.	Particulars	Value
1.	Size of plot, m	25 x 40
2.	Area covered, m^2	450
3.	Duration of test, h	0.6
4.	Speed of operation, km/h	1.80
5.	Row spacing, m	0.60
6.	Depth of seed placement, cm	4.36
7.	Recommended seed rate, kg/ha	15-20
8.	Obtained seed rate, kg/ha	19
9.	Emergence percentage, %	80
10.	Theoretical field capacity, ha/h	0.108
11.	Effective field capacity, ha/h	0.075
12.	Field efficiency, %	69.44
13.	Plant count, No/m^2	9
14.	Obtained plant population, No/ha	74074
15.	Recommended plant geometry, cm	60 x 20 or 60 x25 75 x 20 or 75 x 25
16.	Obtained plant geometry, cm	60 x 22.5

5. SUMMARY AND CONCLUSIONS

5.1 Summary

In the crop production, higher productivity depends upon sowing the seeds. An early or delayed sowing would show adverse effect on crop yield. It depends on seed being placed at equal interval in a row. The spacing of the seed is affected when the mechanism fails to select or drop a seed resulting in the gaps. Keeping this in mind, the present study was undertaken to develop the manually operated single row multicrop planter with the following objectives:

1. To develop a manually operated single row multicrop planter.
2. To conduct functional test of a manually operated single row multicrop planter.

A nylon plastic was used for seeding unit. The nylon plastic has high strength and can withstand in all adverse conditions. The seed rotor had the equidistant cells on its periphery. The row to row spacing was adjusted by varying position of the markers on both sides of the machine.

The planter was tested in both laboratory and field by using seeds of maize (variety “Rajarshi”.). The planter was tested in laboratory for the calibration and to know the seed damage. The planter was field tested in 0.075 hectare area. Field test was conducted at the forward speed of 1.80 km/h. The field trial of the developed planter indicated that it did the intended functions satisfactorily with an average field efficiency of 69.44 % and the field capacity of 0.075 ha/h with Rs.357 per hectare as an average cost of operation.

5.2 Conclusions

Based on the analysis of the results, the following conclusions were drawn.

1. The implement could be used for planting of maize at desired row to row spacing.
2. The performance of seed metering device was satisfactory. It gave seed rate 19 kg/ha during the field trials and seed damage was negligible.
3. The average achieved plant geometry was 60 x 22.5 cm against the recommended plant geometry of 60 x 20 or 60 x 25 cm and emergence percentage was found to be 80 %.
4. The seed singulation was achieved. This resulted in saving of valuable seed and the labour charges required for thinning operation were eliminated
5. The actual field capacity was found to be 0.0754 ha/h.
6. The average field efficiency of the machine was 69.44 per cent.
7. The overall weight of the machine was 20 kg.
8. The cost of implement is about Rs. 2360 /-

9 The cost of operation was Rs. 26.76 per hour and Rs. 357 per hectare.

6. SUGGESTIONS FOR FUTURE WORK

In view of making this manually operated single row multicrop planter more versatile and perfect in all respects, there is a scope for future work. The following suggestions are made for future work:

1. The field trials for different crops need to be conducted to check the performance of the planter for different crops.
2. The angle of repose of the conical seed needs to be optimized for different crops.
3. The seed metering device should be used for bullock drawn and tractor operated planter.

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8. APPENDICES

APPENDIX - I

Moisture Content

Sr. No.	Weight of container + lid (W_1) gm	Weight of container + lid + wet soil (W_2) gm	Weight of container + lid+ dry soil (W_3) gm	Moisture content, % (wb)
1	14.35	38.40	33.50	20.37
2	13.48	37.28	32.65	19.45
3	14.20	36.54	32.50	18.08
4	16.14	36.86	33.45	16.45
5	16.67	38.17	34.23	18.32
			Average	18.53

$$\text{Moisture Content} = \frac{W3-W2}{W2-W1} \times 100$$

Average moisture content = 18.53 % (wb)

APPENDIX – II

Depth of Seed Placement

Sr. No.	Observation
1	4.4
2	4.3
3	4.6
4	4.3
5	4.2
Average	4.36

Average depth of Seed Placement = 4.36 cm

APPENDIX – III

Plant Population per square metre

Sr. No	Observation
1	8
2	9
3	9
4	7
5	9
Average	**9**

Per cent Germination

The germination percentage was calculated by using the following formula:

$$\text{Per cent germination} = \frac{\text{Average no. of plants germinated per sq. m}}{\text{No. of seed sown per sq. m}} \times 100$$

$$\text{Per cent germination} = \frac{4}{5} \times 100$$

Per cent germination = 80 %

APPENDIX – IV

Plant Geometry

Plant to plant distance, cm

Sr. No.	Observation
1	22.20
2	22.50
3	22.45
4	23
5	22.10
6	22.70
7	22.50
8	22.40
9	22.40
10	22.45
Average	**22.47**

Plant Geometry = 60 x 22.47 cm

APPENDIX – V

Field Efficiency, %

1. Theoretical field capacity (ha/h)

The theoretical field capacity was calculated by following formula.

$$\text{Theoretical field capacity,ha/h} = \frac{\text{Working width,m} \times \text{speed,kmph}}{10}$$

$$\text{Theoretical field capacity} = \frac{0.6 \times 1.80}{10}$$

Theoretical field capacity = 0.108 ha/h
= 0.864 ha/day (considering one day of 8 hours)

2. Effective field capacity (ha/h)

It was calculated by following formula.

$$\text{Effective field capacity,ha/h} = \frac{\text{Actuala area, ha}}{\text{Time required, h}}$$

$$\text{Effective field capacity} = \frac{0.045}{0.6}$$

Effective field capacity = 0.075 ha/h
= 0.6 ha/day (considering one day of 8 hours)

3. Field efficiency

Field efficiency was calculated by following formula.

$$\text{Effective field capacity,ha/h} = \frac{\text{Actual area, ha}}{\text{Time required, h}}$$

$$\text{Field efficiency, \%} = \frac{0.6}{0.864} \times 100$$

= 69.44 %

Field efficiency= 69.44 %

APPENDIX – VI

Cost of Operation per Hectare of Planter

A. Fixed cost per hour

It was calculated as following .

1) Depreciation per hour

It is loss of value of planter with passing of time and was calculated by following formula.

$$D = \frac{P - S}{L \times h}$$

Where,

D = Depreciation per hour

P = Capital investment (it was 2350)

S = Salvage value which is 10% of purchase price

L = Total life of planter in years (taken as 10 years)

h = No. of working hours of planter per year (taken as 300 hours per year)

$$D = \frac{2360 - 236}{10 \times 300}$$

D = 0.708

Depreciation per hour = Rs. 0.708

2) Interest per hour

It was calculated on the average investment of the planter taking into consideration the value of the planter in first and last year, calculated by using,

$$I = \frac{P + S}{2} \times \frac{R}{100 \times h}$$

where,

I = Interest to be paid per hour

R = Rate of interest per year (taken as 10%)

$$I = \frac{2360 + 236}{2} \times \frac{10}{100 \times 300}$$

I = 0.43

Interest per hour = Rs. 0.43

3) Housing cost per hour

It was calculated on the basis of the prevailing rates of the market but roughly taken as 1 per cent of initial cost of planter machine per year.

$$\mathrm{H} = \frac{\mathrm{P}}{\mathrm{h}} \times \frac{1}{100}$$

Where, H = Housing cost per hour (taken 1% of Purchase price)

$$H = \frac{2360}{300} \times \frac{1}{100}$$

H = 0.078

Housing cost per hour = Rs. 0.078

4) Insurance

Insurance charges were taken as nil.

5) Taxes

Not applicable hence, it was taken as nil.

Fixed cost per hour = Rs. 1.21

B. Variable cost per hour

It includes total of following costs.

1) Fuel cost

No fuel required. Hence, fuel cost was taken as nil.

2) Lubricants cost

Cost was paid for grease and lubricating oil, but on per hour basis calculations it was negligible. Hence, lubricants cost was also taken nil.

3) Repair and maintenance cost per hour

Generally it varies between 5 - 10 per cent of the initial cost of the planter per year. Here, it was considered 7 per cent of initial cost and calculated as.

$$\text{Repair maintanance cost per hour} = \frac{7 \times P}{100 \times h}$$

$$\text{Repair maintanance cost per hour} = \frac{7 \times 2360}{100 \times 300}$$

$$= 0.55$$

Repair and maintenance cost per hour = Rs. 0.55

5) Wages of operator per hour

One skilled labour was required for operating planter; its charge per hour was taken as **Rs.25**.

Variable cost per hour = Rs. 25.55

C. Total costs (A + B)

Total cost of operation of bullock drawn planter was calculated in Rs. per hour by adding A and B above.

$$\text{Total cost} = \text{Fixed cost per hour} + \text{Variable cost per hour}$$

Total cost = 1.21 + 25.55

= 26.76

Total costs per hour = Rs. 26.76

D. Cost of operation per hectare

Total cost of operation of manually operated planter in Rs/ha was calculated by

$$\text{Cost of operation of planter in Rs/ha} = \frac{\text{Cost of operation of planter (Rs/hr)}}{\text{Actual field capacity of planter in (ha/hr)}}$$

$$\text{Cost of operation of planter, Rs/ha} = \frac{26.76}{0.075}$$

= 356.8

Cost of operation per hectare of planter = Rs. 357

APPENDIX – VII

Specifications of the manually operated single row multicrop planter

Sr.No.	Particulars	Specification
1	**General**	
	Name	Manually operated single row multicrop planter
	Major function	Plant seed at proper spacing and depth
2	**Furrow opener**	
	No. of furrow opener	1
	Depth control adjustment	Using nut and bolts
3	**Metering unit**	
	Seed rotor	Vertical type
	Method of changing seed spacing	Through peripheral cells on rotor
	Material	Nylon plastic
4	**Ground wheel**	
	No.	1
	Type of wheel	Wheel with spokes
	Material	m.s.
5	**Power transmission**	Through chain and sprocket
6	**Overall dimensions**	
	Length, mm	1159
	Width, mm	455
	Height, mm	993
	Weight, kg	20

APPENDIX – VIII

Details of costs of fabrication of Manually Opearated Single Row Multicrop Planter

Sr. No.	Description	Quantity	Rate	Cost (Rs)
1.	m.s. angle, size 25x25x3 mm	1.678 kg	Rs.50/kg	83.93
2.	m.s. round pipe, size 25x3mm	5.33 kg	Rs 50/kg	266.5
3.	m.s. Bright bar (Square bar), size 16x16mm	0.45 kg	Rs.70/kg	31.5
4.	Square pipe furrow opener, size 25x25x3mm	0.97 kg	Rs 50/kg	48.5
5.	Ball Bearing, No.6202Z, size I.D. 15 mm	2 Nos.	Rs.60/pc	120
6.	Sprocket wheel, size 18 teeth, 12.7mm pitch	2 Nos.	Rs. 45/pc	90
7.	Ground wheel, size O.D.500 mm	1 No.	Rs.260/pc	260
8.	Support wheel, size O.D. 22 mm	1 No.	Rs. 70/pc	70
9.	Bicycle chain, standard	1 No.	Rs.60/ chain	60
10.	Seed Rotor	1 No.	Rs.50/pc	50
11.	Miscellaneous (nuts, bolts, washers), size 5/6"	0.25 kg	Rs.50/kg	12.5
12.	Welding rods	45 Nos.	Rs.2/pc	90
13.	Colour	1 lit	Rs.200/lit	200
14.	Marking bar, size 10 mm diameter	0.3 kg	Rs. 50/kg	15
15.	m.s. sheet, thickness 1.25 mm, $1m^2$	9.8 kg	Rs.50/kg	490
	Cost of fabrications (25% of cost of above material)	-	-	471.98
Total cost			**Rs. 2359.91/-**	
i.e			**Rs. 2360 /-**	

9. VITA

NAKATE SHIVPRASAD MADAN

A candidate for the degree

of

MASTER OF TECHNOLOGY

(AGRICULTURAL ENGINEERING)

FARM MACHINERY AND POWER

Title of thesis : "DEVELOPMENT OF MANUALLY OPERATED SINGLE ROW MULTICROP PLANTER"

Major Field : FARM MACHINERY AND POWER

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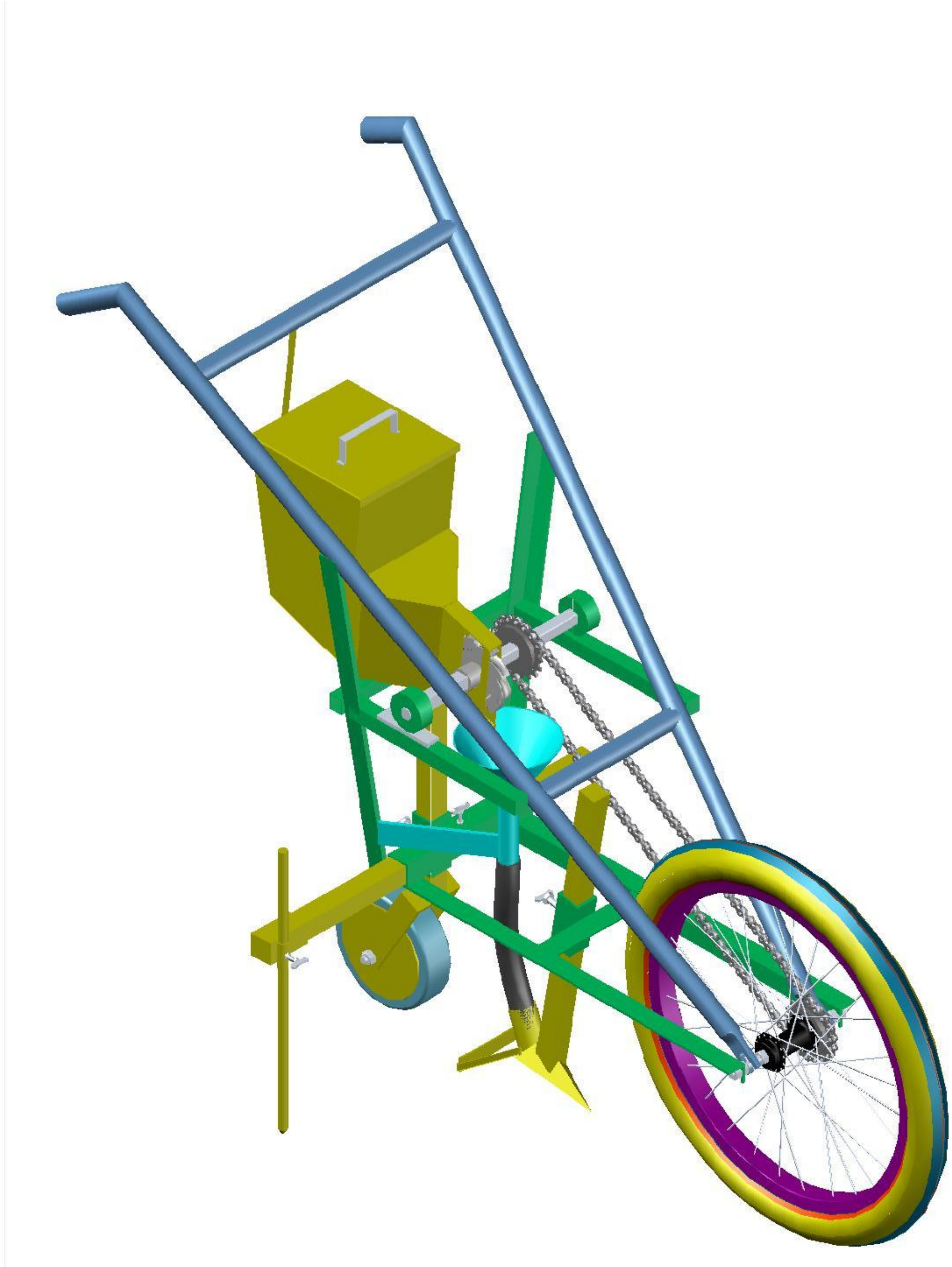


Fig. 3.1 Three Dimensional View of Manually Operated Planter

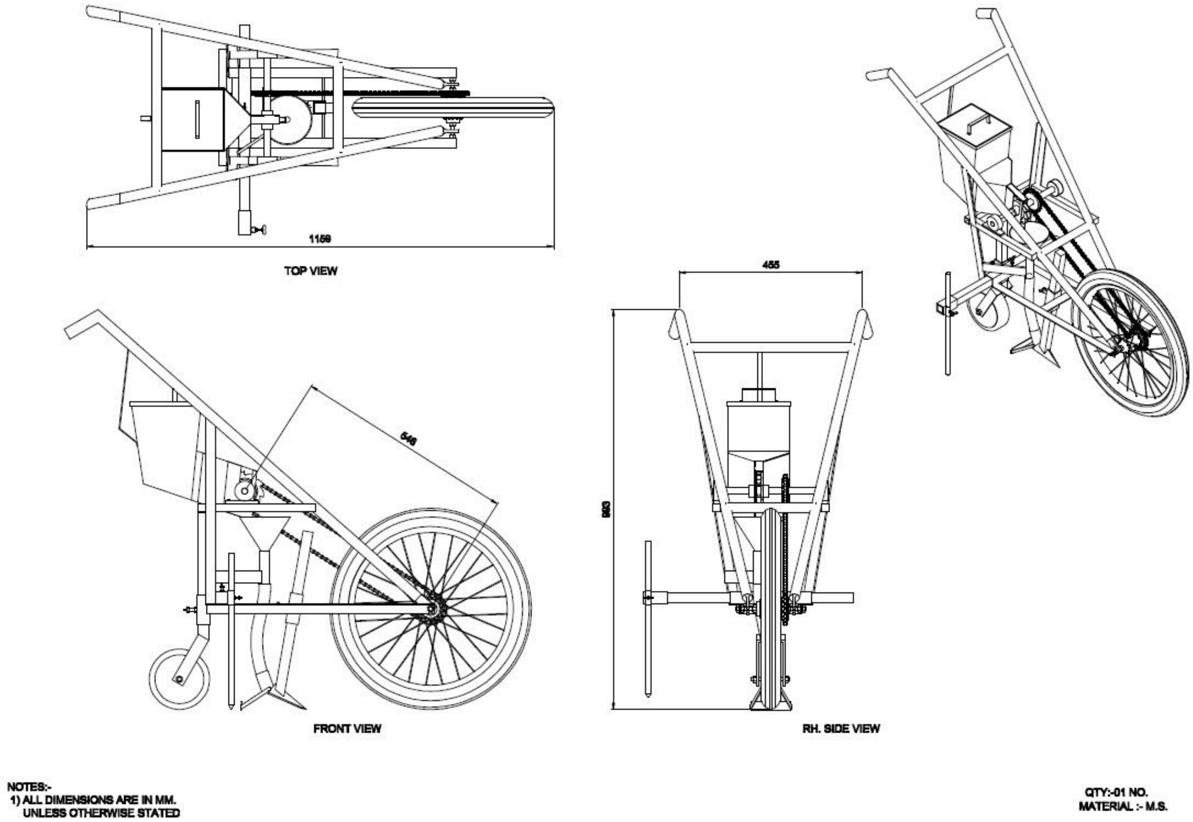


Fig. 3.2 Orthographic View of Manually Operated Planter

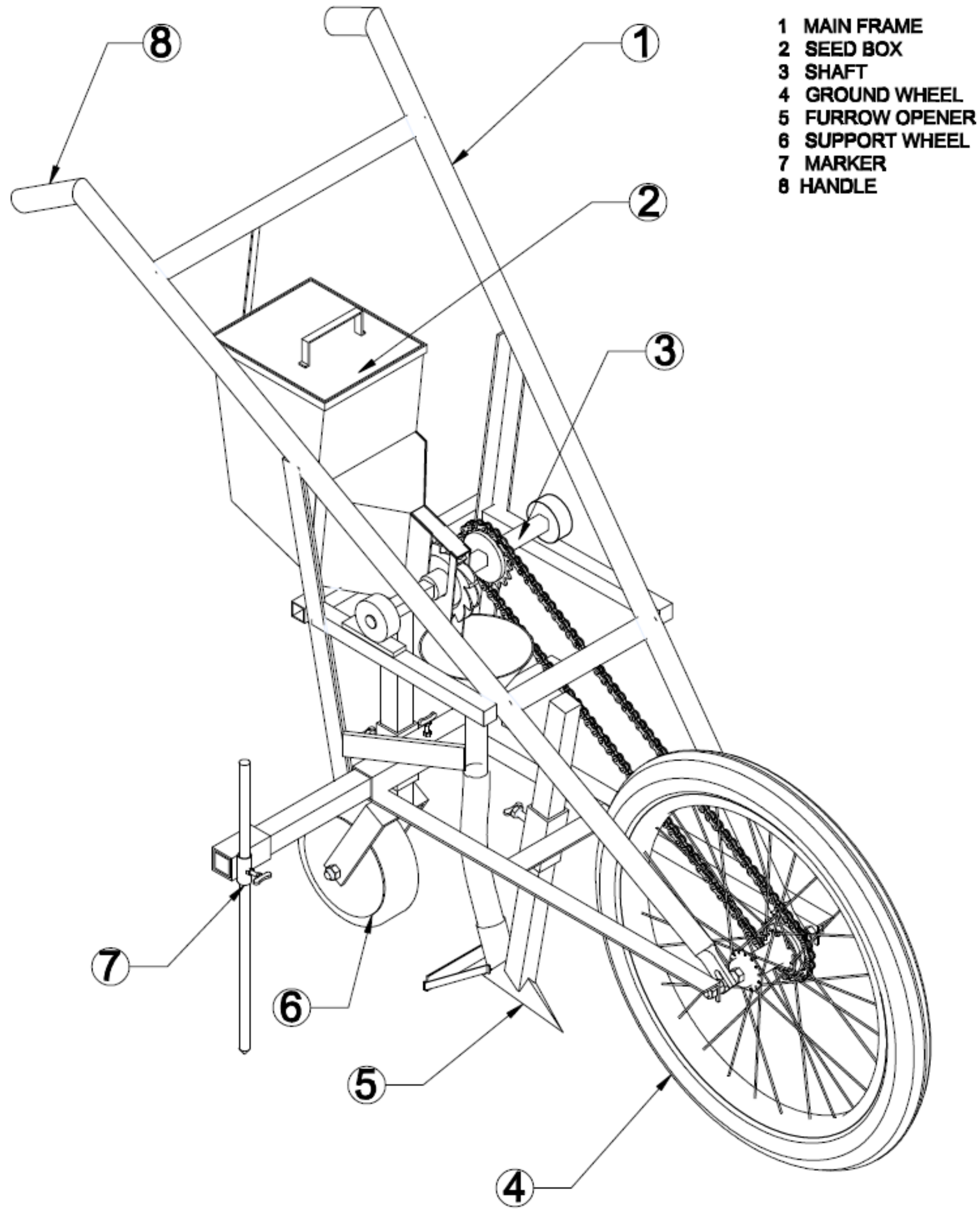


Fig. 3.3 Isometric View of Manually Operated Planter

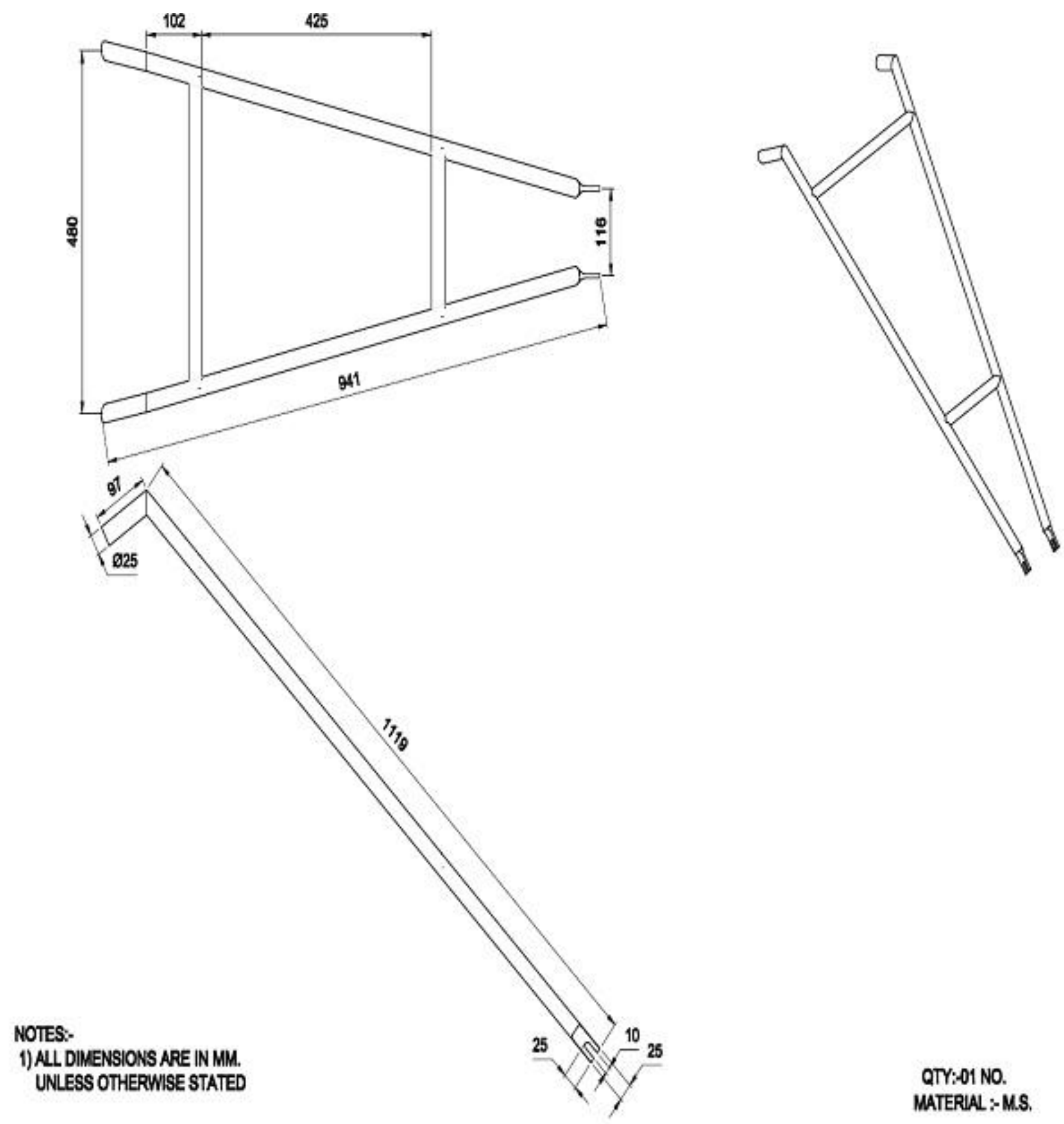


Fig. 3.4 (a) Main Frame

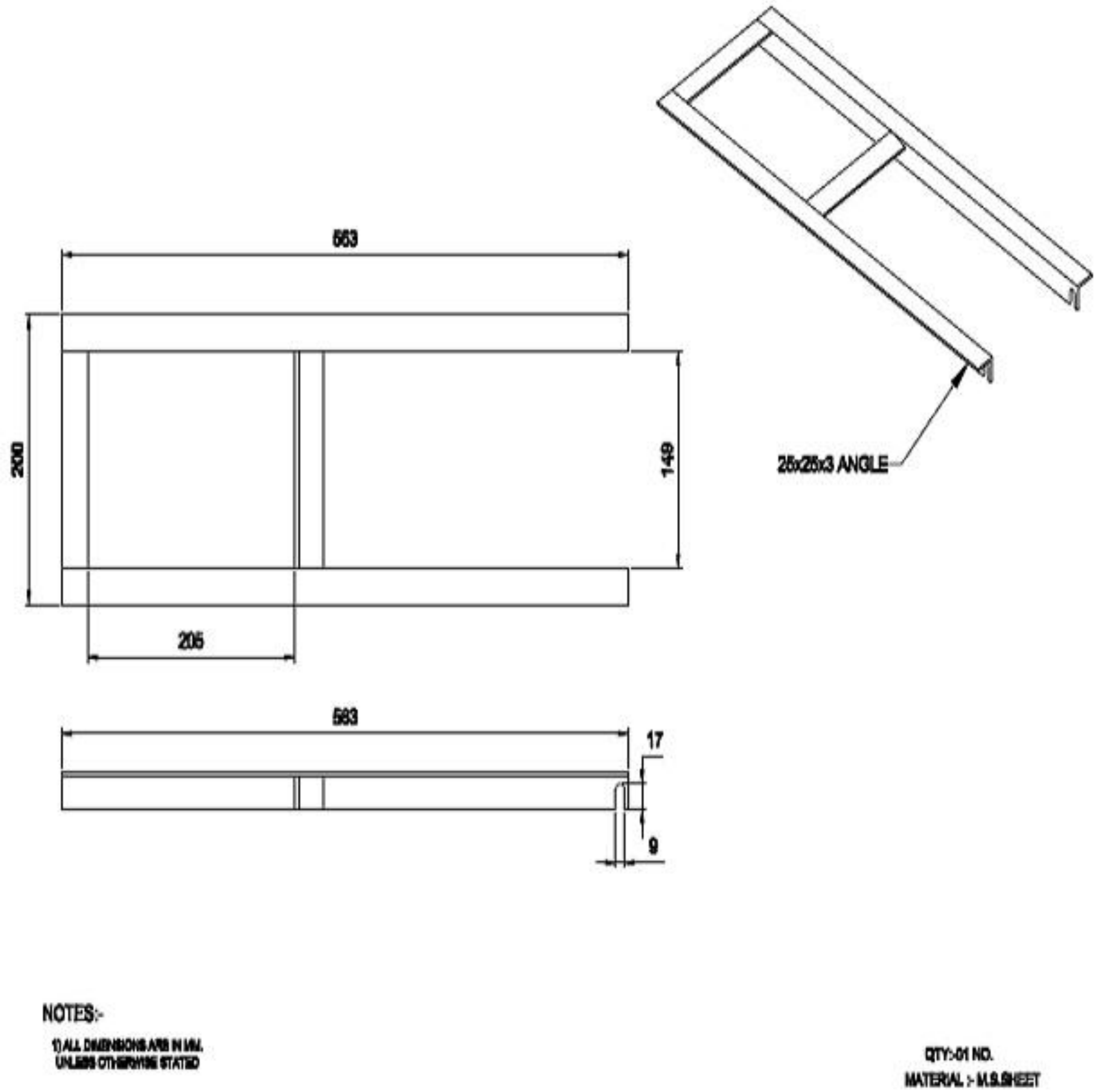


Fig. 3.4 (b) Main Frame

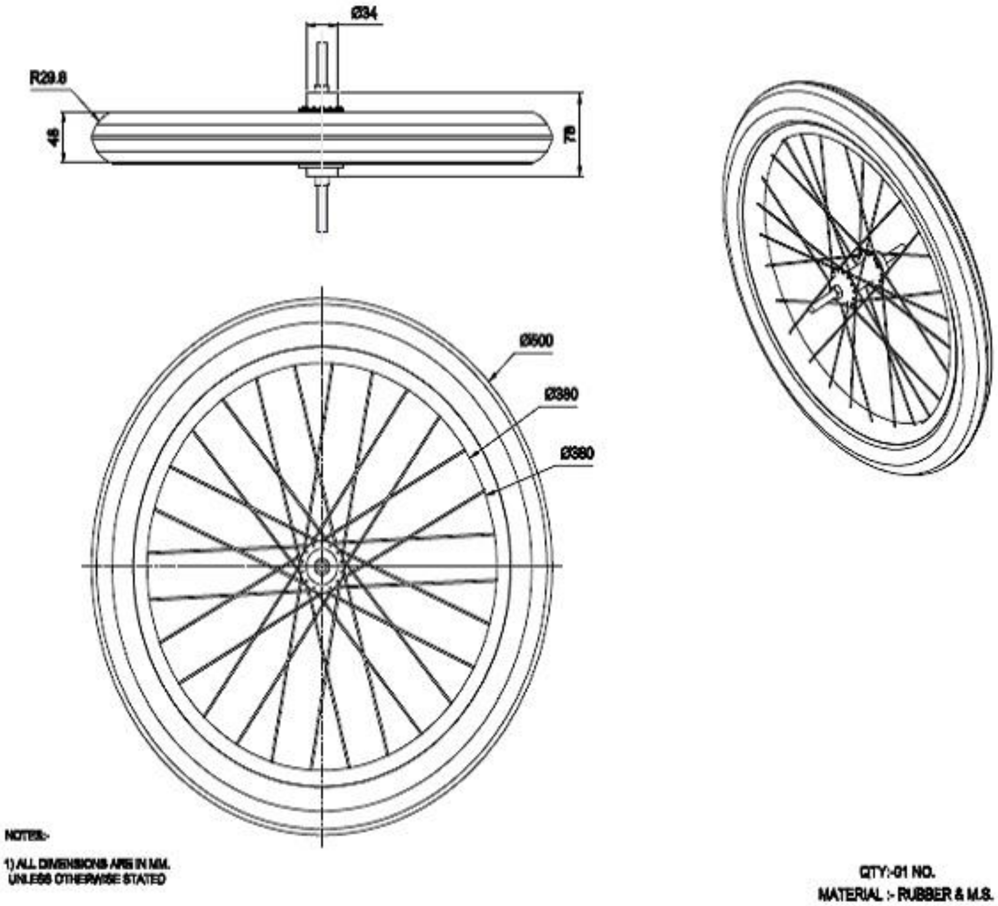


Fig. 3.5 Ground Wheel

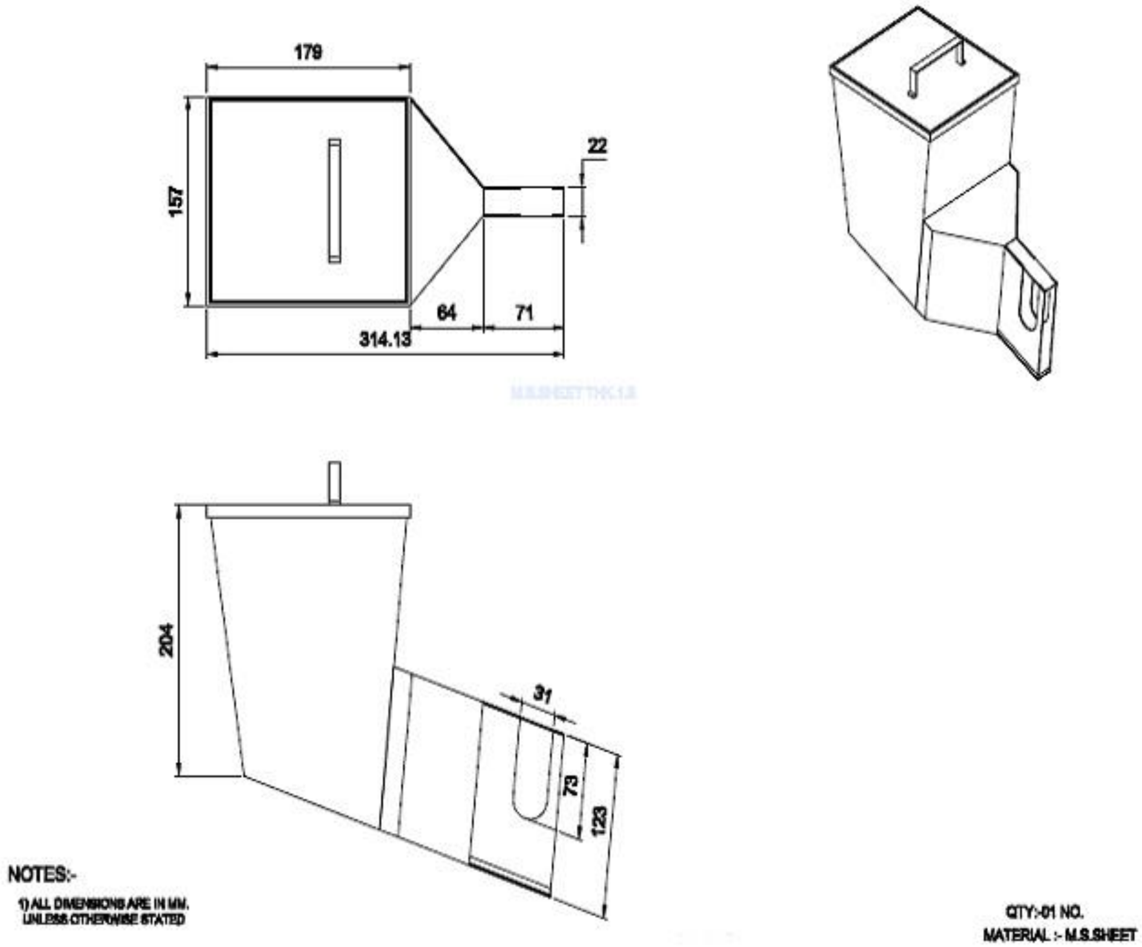
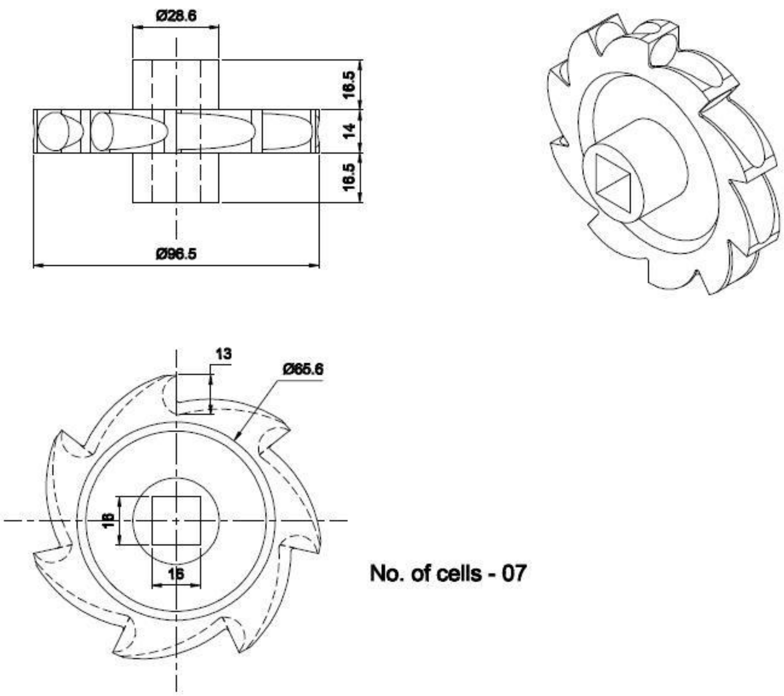


Fig. 3.6 Seed Box



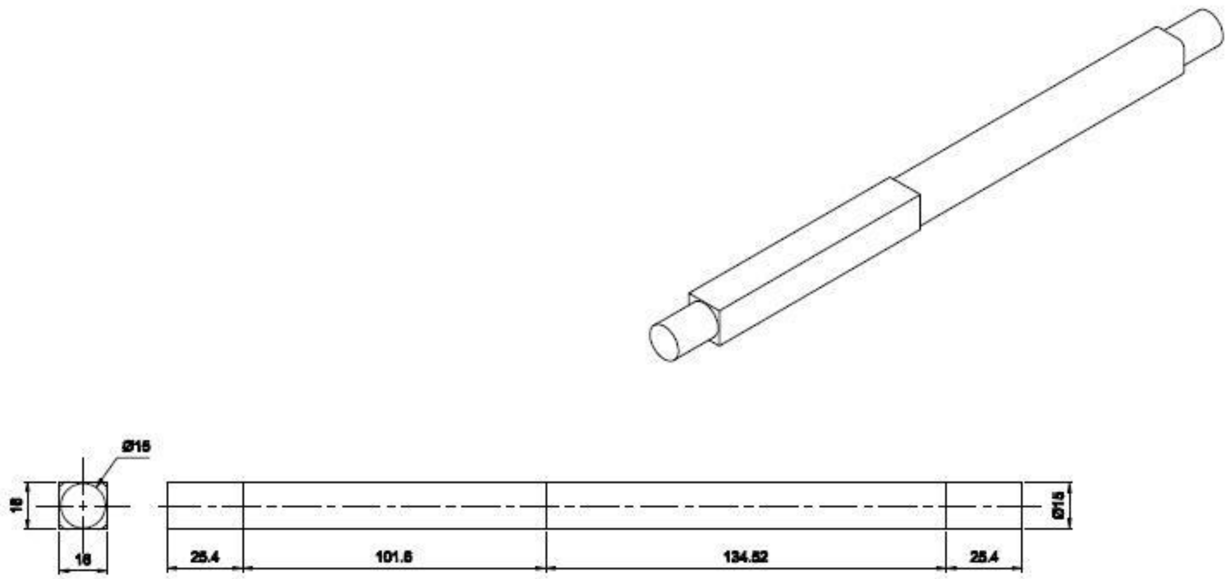
No. of cells - 07

NOTES:-

1) ALL DIMENSIONS ARE IN MM.
UNLESS OTHERWISE STATED

QTY:-01 NO.
MATERIAL :- NYLON PLASTIC

Fig. 3.7 Seed Rotor



NOTES:-

1) ALL DIMENSIONS ARE IN MM.
UNLESS OTHERWISE STATED

QTY:-01 NO.
MATERIAL :- M.S.

Fig. 3.8 Shaft

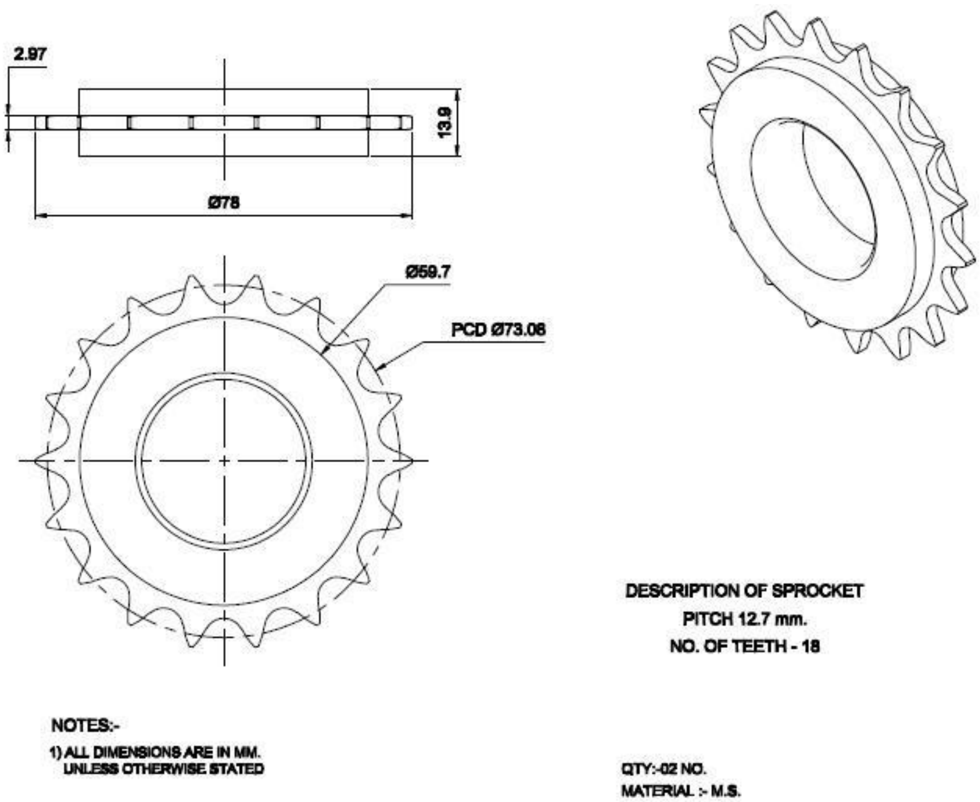


Fig. 3.9 Sprocket

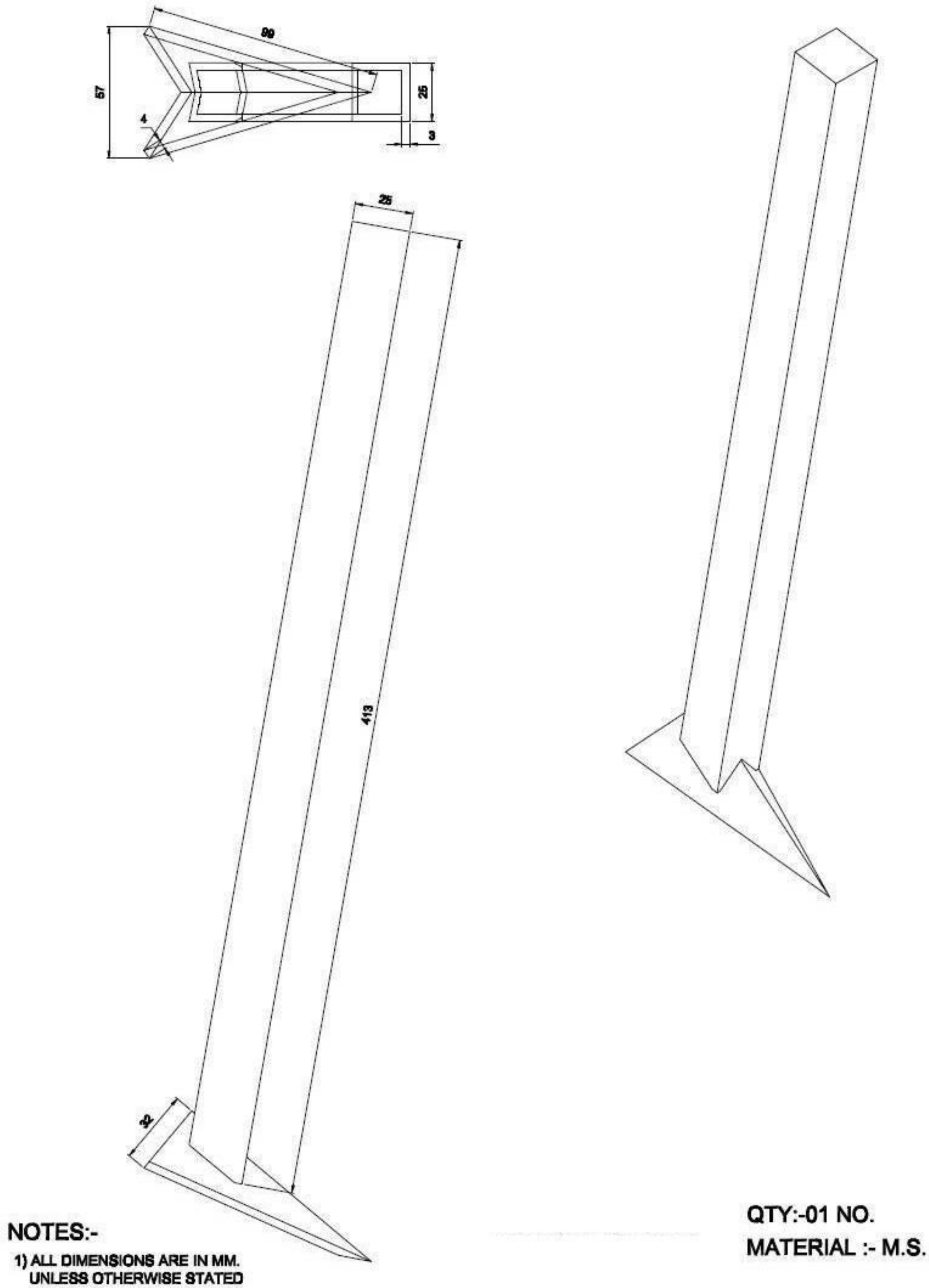
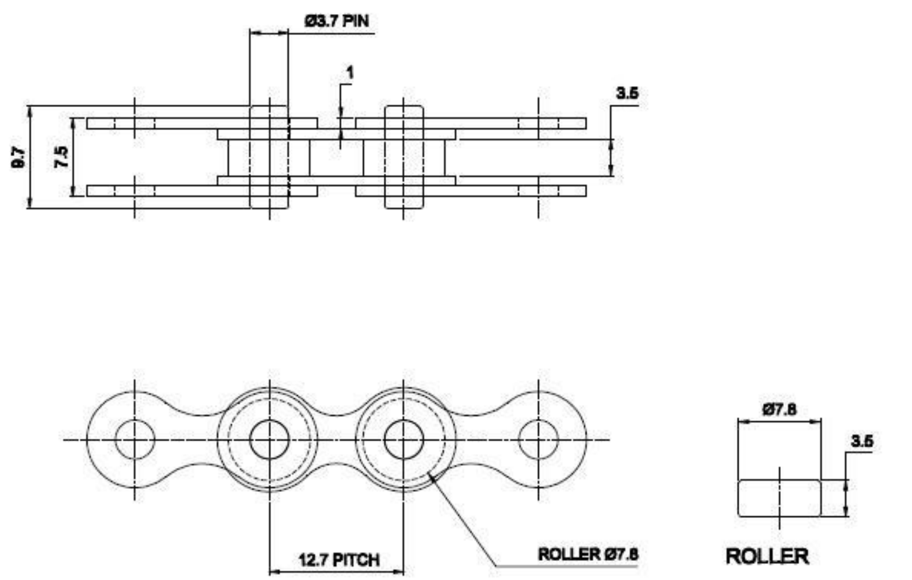


Fig. 3.10 Furrow Opener



NOTES:-
1) ALL DIMENSIONS ARE IN MM.
UNLESS OTHERWISE STATED

MATERIAL :- M.S.

Fig. 3.11 Chain

Plate 3.1 Front view of manually opeated single row multicrop planter

Plate 3.2 Side view of manually opeated single row multicrop planter

Plate 3.3 Top view of manually opeated single row multicrop planter

Plate 3.4 Seed Rotor

Plate 3.5 Sprocket

Plate 4.1 Ground Wheel

Plate 4.2 Manually operated single row multicrop planter in operation

Plate 4.3 View of maize crop planted by manually operated single row multicrop planter

Plate 4.4 Plant geomentry

Plate 4.5 Measurement of plant population