"DEVELOPMENT OF MANUALLY OPERATED ONION SEED PLANTER."

Thesis

Submitted to the

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

by

Borkar Kumudini Mohanlal

B. Tech. (Agril. Engg.)

In partial fulfilment 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,
MAHATMA PHULE KRISHI VIDYAPEETH,
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December, 2012

CANDIDATE'S DECLARATION

I hereby declare that this thesis entitled **"DEVELOPMENT OF MANUALLY OPERATED ONION SEED 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. (**Borkar Kumudini Mohanlal)**

Date: / / 2012 (Reg. No. 10/15)

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CERTIFICATE

This is to certify that the thesis entitled, "**DEVELOPMENT OF MANUALLY OPERATED ONION SEED PLANTER**" submitted to the Faculty of Agricultural Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri, District-Ahmednagar, Maharashtra State, in partial fulfilment of the requirement for the degree of **MASTER OF TECHNOLOGY (AGRICULTURAL ENGINEERING)** in **FARM MACHINERY AND POWER,** embodies the results of a piece of bonafide research work carried out by **Miss. Borkar Kumudini Mohanlal** *(Reg. No. 10/15)*, under my guidance and supervision. The results embodied in this thesis have not been submitted to any other University or Institute, for the award of any Degree or Diploma.

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

Place: M.P.K.V., Rahuri

Date: / / 2012 **(A. B. Lende)**

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

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Place: M.P.K.V. Rahuri

Date: / / 2012 **(P.A. Turbatmath)**

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Place: MPKV, Rahuri.

Date: / / 2012 **(Borkar Kumudini Mohanlal)**

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LIST OF ABBREVIATIONS

Abbreviation	Description
ADR	Agrifound Dark Red
Agril.	Agricultural
Agric.	Agriculture
AICRP	All India Coordinated Research Project
AINRPOG	All India Network Project on Onion & Garlic
ALR	Agrifound Light Red
ASAE	American Society of Agricultural Engineers
BBF	Broad Bed Furrow
B. Tech.	Bachelor of Technology
CAET	College of Agricultural Engineering and Technology
cm	Centimetre
DAP	Di Ammonium Phosphate
Dr. A. S. C. A. E.	Dr. Annasaheb Shinde College of Agricultural Engineering
Dr. P.D.K.V.	Dr. Panjabrao Deshmukh Krishi Vidyapeeth
Engg.	Engineering
et al.	and others
etc.	Et cetera
FIM	Farm Implements and Machines
Fig.	Figure
FMP	Farm Machinery and Power
g	Gram
g kg^{-1}	Gram per kilogram
gm^{-2}	Gram per meter square
GDP	Gross Domestic Product
h	Hour
ha	Hectare
ha h^{-1}	Hectare per hour
hp	Horse Power
ICAR	Indian Council of Agricultural Research

J.	Journal
kg	Kilogram
kgf	Kilogram force
kg ha^{-1}	Kilogram per hectare
km	Kilometre
km h^{-1}	Kilometre per hour
m	meter
mm	Millimetre
Man-days ha^{-1}	Man days per hectare
Man-h ha^{-1}	Man hours per hectare
min.	minute
m min^{-1}	Meter per minute
mph	Meter per hour
M. P. K. V.	Mahatma Phule Krishi Vidyapeeth
MPUAT	Maharana Pratap University of Agriculture and Technology
M.S.	Maharashtra State
m.s.	Mild Steel
ms^{-1}	Meter per second
N	Newton
NHRDF	National Horticultural Research and Development Foundation
No.	Number
PD	Pratiyogita Darpan
PN	Punjab Naroya
PVC	Poly Vinyl Chloride
Reg.	Registration
RNAM	Regional Network for Agricultural Machinery
RPM	Revolutions per minute
Rs.	Rupees
TNAU	Tamil Nadu Agricultural University
viz.	Namely
$ZnSO_4$	Zinc sulphate

Symbol

%	Per cent
^{o}	Degree
&	And

ABSTRACT

DEVELOPMENT OF MANUALLY OPERATED ONION SEED PLANTER

By

Borkar Kumudini Mohanlal

(Regn. No. 10/15)

A candidate for the degree of

MASTER OF TECHNOLOGY

(AGRICULTURAL ENGINEERING)

in

Farm Machinery and Power

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December, 2012

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. Agriculture occupies an important position in India as it contributed nearly 14.6% of the GDP in 2009-10 and provided employment to 52 % of country's work force and is the single largest private sector occupation (PD Indian economy, 2011-12). 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.

Onion (*Allium cepa L.*) is one of the most important vegetable crops grown throughout the country. It is widely grown in different parts of the country mainly by small and marginal farmers. Generally, the onion crop can be grown in the field in three methods: by raising seedlings in the nursery and then transplanting them in field, by planting bulbs directly in the field, and by broadcasting or drilling seeds directly in the field. Transplanting of seedlings is the most labour intensive operation, which is presently done manually in India.

Abstract Contd… **K. M. Borkar**

In direct seeding method, which is labour saving, soil is thoroughly pulverized and made free of clods. In this method, the required plant spacing is not maintained. Also, one more operation required, i.e. thinning. The seed of onion is of very small size, having low density and irregular shape which poses problem in precision planting. In India very little effort has been done for seed pelleting and development of precision planter / drill for sowing the small size, light weight and irregular shaped seeds. Keeping this in mind, the present study was undertaken to develop the manually operated onion seed planter.

In order to achieve this objective, the seed planter consisting of main frame, seed metering mechanism and power transmission unit was developed. The m.s. material 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 furrow openers.

Tests indicated that weight of machine was 20.5 kg. Its average field efficiency was 83.33 % and the field capacity of 0.09 ha h^{-1} with Rs.368 per hectare as an average cost of operation. Machine showed satisfactory results and it was suitable for small and marginal farmers.

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1. INTRODUCTION

Agriculture occupies an important position in India as it contributed nearly 14.6% of the GDP in 2009-10 and provided employment to 52 % of country's work force and is the single largest private sector occupation. The contributory share of agriculture in GDP was 55.4 % in 1950-51, 52 % in 1960-61 and is reduced to 14.6 % only in 2009-10 (PD Indian economy, 2011-12). Growth of agriculture over a period remained lower than the growth in non-agriculture sectors and this decelerating trend is cause for concern. Various constraints and disturbing trends have always continued to hamper the requisite growth of the agriculture sector, such as agriculture still gambles in monsoon, failure of land reforms and limited use of agricultural machinery.

One important emerging feature of Indian agriculture is the increasing number of marginal (less than 1 ha) and small size holdings (1.0 to 2.0 ha). 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 the need of time to make a technology according to their need and in such a way that they could afford it.

Vegetables are considered protective foods and also play an important role in providing a balanced diet to human beings. They are of short duration and therefore, more number of crops can be grown per year. Due to shrinkage of agricultural land due to urbanization and industrialization, cultivation of vegetable crops will be more economical. Presently, horticultural crops occupy around 10 % of gross cropped area of the country producing 160.75 million tones. India is the second largest producer of fruits and vegetable in the world after China. India's share in world vegetable production is 13.28 %. India occupies second rank in the production of onion in the world next to China (PD Indian economy, 2011-12).

Onion (*Allium cepa L.*) is one of the most important vegetable crops grown throughout the country. It is widely grown in different parts of the country mainly by small and marginal farmers. In Maharashtra and Gujarat, this crop has gained the importance as cash crop rather than a vegetable crop because of its very high export potential. Maharashtra alone contributes 21.59 % of the total national production (India stat 2010-11). Nasik district alone contributes 48-49 % of the state's production (India Stat 2003-04). In India, Maharashtra is a leading onion growing state followed by Karnataka (17.34%), Gujarat (12.46%), etc. (India Stat 2010-11).

Onions are used as spices, condiments and vegetables almost daily in every kitchen as a seasoning for wide varieties of dishes. Onions are a rich source of calories, vitamin C and minerals, especially iron, phosphorus and calcium. It is also known to possess several medicinal properties. Its consumption helps in prevention and treatments of arthritis, coronary heart diseases, diabetes, cancer and asthma. A chemical composition called 'quercetin' present in onion is a powerful antioxidant. An ointment or paste made from onion is said to prevent infection in wounds and burns. Onion bulb (Per 100 g edible part) contains 86.6 percent moisture, 11.1 g carbohydrates, 1.2 g protein, 0.1 g fat, 0.08 mg thiamine, 0.01 mg riboflavin, 11mg vitamin C, 47 mg calcium and 0.7 mg iron (Anonymous, 2009a).

Generally, the onion crop can be grown in the field in three methods (Rai and Yadav, 2005):

1. By raising seedlings in the nursery and then transplanting them in field,
2. By planting bulbs directly in the field, and
3. By broadcasting or drilling seeds directly in the field.

In nursery raising method, the onion seeds are first sown in nursery and then the raised seedlings are transplanted in the field with row to row spacing of 15 cm and plant to plant spacing of 10 cm (*kharif* season) and 12.5 cm x 7.5 cm (*rabi* season) to get optimum yield (Krishi Darshani, 2009). Advantages of this method are an intensive care of seedlings is possible in nursery as the area is very small and proper plant spacing can be maintained while transplanting. But it has some disadvantages also. Transplanting of seedlings is the most labour intensive operation, which is presently done manually in India. The labour requirement in manual transplanting of onion seedlings is as high as 80 – 100 man-daysha^{-1} as 8.9 lakh seedlings per hectare are to be transplanted (Rathinakumari *et al*. 2003). Because of high requirement and shortage of labour, the area under onion cultivation is reducing and can be increased by mechanization of this crop.

Work on semi automatic transplanters has been done in India for sowing of wide row and widely spaced vegetable crops, whereas very little work has been done on transplanting of onion. A tractor operated onion transplanter was developed at MPUAT, Udaipur, which has field efficiency of 70.5 – 71.60 % and missing percentage as 5.0 – 5.7 % (Turbatmath, 2011).

In bulb method of planting, bulbs are dibbled 15 cm on the side of 45 cm wide ridges or in beds. To plant one hectare, 750 kg of medium sized bulbs is required. Large sized bulbs, if planted, tend to flower early and resulted in low yield (Yawalkar, 1969).

Onion can also be grown by direct seeding method which is labour saving. In this method of planting, soil is thoroughly pulverized and made free of clods. In this method, the required plant spacing is not maintained. Also, one more operation required, i.e. thinning. The seed of onion is of very small size, having low density and irregular shape which poses problem in precision planting. To overcome these difficulties, ‘Seed Pelleting Technique’ is being used in the developed countries. In this seed is enclosed into small quantity of inert material just large enough to produce a globular unit of standard size to facilitate precision planting. But, the coating delayed seed germination (Barut, 2008). In India very little effort has been done for seed pelleting and development of precision planter / drill for sowing the small size, light weight and irregular shaped seeds.

Keeping in view, the aforementioned aspects, a study was planned to develop a manual mechanical planting mechanism for direct sowing of onion seed with the following objectives:

1. To develop a manually operated onion seed planter.
2. To conduct functional trials of the manually operated onion seed 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. Agronomy of onion crop.
2. Physical properties of onion seeds.
3. Development of seed drills and planters.
4. Development of seed metering mechanisms.
5. Transplanters for vegetable crops.

2.1 Agronomy of Onion Crop

Dharmendra *et al.* (2001) conducted an experiment to study the effect of spacing (20x10, 20x15 and 20x20cm) on the growth and yield of onion during 1992–93 and 1993–94. The wider spacing (20x20cm) showed maximum plant height, number of green leaves, diameter of longest leaf, diameter of pseudostem, number of roots, bulb length, diameter of bulb and fresh weight of bulb in comparison of closer spacing of 20x15 and 20x10 cm. However, the maximum yield of bulbs was obtained when the plants were spaced at 20x10 cm.

Sukhadia *et al.* (2002) studied the response of onion to methods of sowing and weed management practices. They revealed that onion could be grown equally profitable either by transplanting or broadcasting. Effective, efficient and economic weed management was achieved through pre-emergence application of fluchloralin or pendimethalin at 0.9 kg ha^{-1} supplemented with one hand weeding at 40 days stage of crop. Oxidiazonat 0.75 kg ha^{-1} proved effective against *Digera arvensis* and *Eclipta alba*.

Anonymous (2004b) studied the influence of seed pelleting and planting methods in *kharif sown* onion. The various seed pelleting materials such as DAP, Borax, $ZnSO_4$, bavistin, Azospirillum, trichoderma, micronutrient mixture, karanj leaf and karanj powder were used for seed pelleting. The well dried pelleted seeds were sown in raised and flat beds during *kharif* season 2003. The results revealed that there was no effect of these treatments on bulb yield. The seeds sown on raised beds gave significantly higher yields than flat beds.

The study was undertaken by **Boyhan *et al.* (2008)** to evaluate direct-seeded onions as an alternative production method. This study evaluated variety, sowing date, and fertility on direct seeding short-day onions in southeastern Georgia. Neither variety nor sowing date significantly affected plant stand or plant spacing.

Anonymous (2010) conducted a field trial under AINRPOG programme at RRS, Nashik during rabi 2009-10 to evaluate the effect of seed coating on direct seeded onion variety ALR. The result revealed that, the coating of seed with DAP @ 30 g kg^{-1} of seeds + Zinc Sulphate @ 0.1 g kg^{-1} of seed + Bavistin @ 3 g kg^{-1} of seed gave better performance regarding yield and yield contributing traits.

Anonymous (2010a) studied the effect of sowing and seed rate on onion production (direct seeded crop). The experiment was conducted during *rabi* season in 2009-10 at RRS, Nashik by using variety ALR. Seed was coated with DAP @ 30 g + Borax @ 0.1 g + Bavistin @ 3g kg^{-1} of seed and sown on 4 different dates. The data revealed that the 15^{th} November sowing with 1 gm^{-2} seed rate gave highest bulb yield.

2.2 Physical Properties of Onion Seeds

Chhina and Sharma (2011) studied the physical properties namely size, shape, thousand grain weight, angle of repose, bulk density and coefficient of static friction for three cultivars of onion i.e. Punjab Naroya (PN), Agrifound dark red (ADR) and Agrifound light red (ALR) and were compared with pelleted seeds. The geometric mean diameters were 1.85, 1.88, 1.95 and 4.35 mm for Punjab Naroya, ALR, and ADR and for the pelleted onion seeds, respectively. The average values of angle of repose for the cultivars under study as observed in the laboratory were 24.12, 25.14, 25.18, and 19.21 respectively for Punjab Naroya, ALR, and ADR and for the pelleted onion seeds. The values of porosity are nearly same for the ALR, ADR and pelleted seeds whereas the porosity for Punjab Naroya was 0.47 and was the lowest amongst the other cultivars. The porosity of pelleted seed was the highest (0.57).

2.3 Development of Seed Drills and Planters

Gray *et al.* (1995) conducted experiments with onion, leek and lettuce to examine the influence of dibber and coulter drills on seedling establishment. In some of the experiments Alcosorb was applied to cover the seeds in the dibbed holes and Soiltex was applied as a band to the soil above the line of seeds. Additionally, seeds of differing quality and primed seeds were used. The dibber drill gave more uniform depth of sowing and spacing between seed positions than the coulter drills and it improved seedling emergence, substantially, where a soil cap or crust formed after sowing, and sometimes gave earlier and more uniform seedling emergence.

Rathinakumari *et al.* (2003) developed a manually operated drum seeder for onion. The seeder consisted of 90 mm diameter PVC pipe with the holes of 3 mm diameter for dropping the single seed in the rows at spacing of 8 cm and plant spacing of 6 cm. The shovel type furrow openers were provided for placing the seeds at proper depth. The field capacity of seeder was 0.09 hah^{-1}, saved 70 % of time in comparison to manual broadcasting and it cost Rs. 300 only.

Jayan and Kumar (2004) studied and evaluated the physical properties namely, length, breadth, surface area, roundness, equivalent diameter, sphericity, seed weight, true density, angle of repose and coefficient of restitution of maize, red gram and cotton seeds as design parameters for a planter. Thickness and cell diameters of the seed metering discs were designed in reference to the maximum breadth and length of seeds. Both roundness and sphericity affect seed flow through the various components of the planter. To ensure free flow of seeds, the slope of the seed hopper was, therefore, fixed at 30^o, which was modestly higher than the average angle of repose of seeds. In addition, the inner surfaces of the seed transfer cup was embedded with 3 mm thick rubber sheet as its coefficient of restitution was lower than mild steel sheet of same thickness.

Ivancan *et al.* (2004) found that how the drilling speeds affected the quality of sowing parsley (*Petroselinum crispum* Mill.) with the Stanhay precision drill S 870. An increase in operating speed resulted in a decrease of drilling precision because the intra-row seed spacing became larger than that required.

Parish and Bracy (2004) evaluated an Earthway garden seeder (model 1001B), which was frequently used for seeding small research and demonstration plots as well as home gardens. Performance with the Earthway seeder with most vegetable seeds would not qualify it as a precision seeder, but the Earthway seeder could do an acceptable job of planting many vegetable seeds in small plots at less than $1/10^{th}$ the cost of a commercial-quality precision seeder.

Yasunobu *et al.* (2004) developed a seeding machine for Paperpot system in which approximately 10 seeds of Welsh onion seeds without seed coat were sown in 1 hole. They examined the cell of a cell roll structure, the rotary brush and the cell roller cover, and made a prototype using the frame of a seeding machine as a basis. The result of practical trial indicated that there was no mechanical trouble with the seeding machine.

Altuntas *et al.* (2006) evaluated the effect of different types of furrow opener and operation speed on soil properties, draft force and percentage of emerged tuber seedlings. Soil penetration resistance increased with increasing operational speeds for each furrow opener type. The lowest soil penetration resistance, draft force and high percentage of emerged tuber seedling occurred found with shovel type furrow opener.

Krzaczek *et al*. (2006) researched on the quality of seeding *Sida hermaphrodita Rusby* (Virginia fanpetals) seeds with the S071 KRUK precision seeder in field conditions. They observed that the best quality of sowing for the examined classes of distances in a row was obtained at the sowing disk peripheral speed of 0.23 ms^{-1} and the working speed of 0.8 ms^{-1}. They concluded that the peripheral speed of the sowing disk of the examined seeder impacted the precision of seed distribution in a row.

Durairaj and Duraisamy (2008) developed portray seeder which could hasten the job of picking and placing singulated seeds or seed pellets into the portray cells. The seeder was evaluated and was found to perform with an efficiency of 95 %. The cost of the needle tray seeder was Rs. 10000 and with capacity of 860 trays per hour. It could save the cost by 50 % and the labour by 60%.

Mali (2011) studied the feasibility of BBF planter, developed in Department of FPM, Dr. PDKV, Akola, for *rabi* crops to identify the various performance parameters, cost of sowing and the net energy. The planter was used for preparing broad bed and furrows and simultaneously sowing of seed on beds. Numbers of plants per hectare observed in laboratory testing were 327666, 109556 and 509000, respectively for chickpea, safflower and onion. Seed rate of 76.74 kg ha^{-1}, 13.39 kg ha^{-1} and 5.55 kg ha^{-1} for chickpea, safflower and onion crop respectively, was obtained during the test. Visible damage observed in laboratory was 1.66, 3.33 and 6.50 % in chickpea, safflower and onion, respectively.

2.4 Development of Seed Metering Mechanisms

Bansal *et al.* (1989) studied the roller-type positive feed seed metering mechanism. It consisted of two rollers with 45° inclined ends assembled on a hexagonal shaft such that the gap width between the rollers could be adjusted. The rollers rotated inside a circular tube fitted below the hopper. Results of a performance study of this mechanism showed that varying the gap between the rollers and the speed of their rotation had a positive effect on the seeding rate for wheat, barley and lentil. The roller feed mechanism had potential for use on low cost seed drills.

Parish and Bracy (1998) reviewed on metering of non-uniform vegetable seed. Seed lots (graded and ungraded) of two turnip (*Brassica rapa* L. rapifera group) cultivars were metered with a belt seeder using belts with holes 3/32 inch (2.4 mm) or 7/64 inch (2.8 mm) in diameter or with a vacuum seeder. Neither the belt nor vacuum seeder satisfactorily singulated any of the seed lots. With the larger (7/64 inch) belt holes, there were excessive incidences of multiple seeds per drop. With the smaller (3/32 inch) belt holes, multiple drops and missed seed were excessive. The vacuum seeder also resulted in excessive misses and multiples.

Ryu and Kim (1998) designed a roller type metering device for precision planting. The design parameters affecting the uniformity of seed placements were investigated from the geometry of roller and brush and the roller was designed accordingly. Experimental results showed that the designed metering roller made a better performance of seed placement than that made by the previous one. The method could also be applied to the design of metering devices for precision hill dropping of other crops.

Guler (2004) studied the effects of flute diameter, fluted roll length and speed on Alfalfa seed flow. He concluded that in order to get an even flow of alfalfa seeds from fluted feed rolls, the flute diameter should be 6 to 8 mm and the rolls should also be run using active roll lengths of 15 to 25 mm at fluted roll speeds of 20 to 40 rpm.

Dhalin *et al.* (2005) evaluated a power tiller operated cup feed seeder, developed in the Department of Farm Machinery, Tamil Nadu Agricultural University, India to assess the uniformity of seed spacing in the row. A check valve system was incorporated with the cup feed seeder, so that the hill to hill drop distance (the plant spacing) could be maintained properly. The field capacity of the seeder with check valve was lesser by 11.2 to 34.5 % than that of the seeder without the check valve. However, the hill spacing improved the plant geometry so much that all the consequent operations for the crop were efficient.

Singh *et al*. (2006) developed a test rig with provision to accommodate various seed metering units for mechanical metering of sunflower seeds. These seed metering units were mounted in the hoppers with an angle of repose equal to that in original drills. A speed of 7.97 to 9.66 m min^{-1}. was found suitable for mechanical metering of sunflower seed. A uniformly shaped cell type (triangular small cell) with aluminum casting having 8 cells on its periphery was found suitable.

Boydas and Turgut (2007) studied that the flow of seed carried by studded feed roller mechanism was affected by constructional and operational variables and by the levels of vibration produced by soil roughness, large aggregates, small stones and motion of tractor. While the levels of vibration had no effect on the flow evenness of wheat, the flow evenness of barley was significantly affected by vibration. Increasing seed rate significantly improved seed flow evenness.

Ahmadi *et al*. (2008) developed a precision seed drill for oilseed rape with a roller-type-metering device and a depth control system. In the laboratory test, it was found that the precision seed drill performed satisfactorily and its speed and vibration did not affect the performance of metering system significantly. In the field test, a uniform distribution of seed with a reasonable spacing along the row planting was achieved and seed scattering was found to be within an acceptable range.

Sahoo and Srivastava (2008) evaluated four different types of metering systems on the basis of their performance parameters i.e. average spacing, quality of feed index, multiple index, miss index, degree of variation and seed damage for metering soaked okra seed at three levels of cell size and four levels of cell speed. The average spacing observed was close to the theoretical spacing for cell size equal to maximum seed dimension. The quality of feed index was influenced highly by metering systems, cell size and cell speed. The metering systems influenced the seed damage the most followed by cell size. They concluded that inclined plate metering system was best suited for metering soaked okra seed.

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 sensed 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.

Reis and Forcellini (2009) conducts the functional test of precision mechanical seed meter for small seeds. Laboratory tests were made to access the percentage of cell fill, the regularity of longitudinal distribution of seeds and the mechanical injury to the seeds. The conclusions were: the percentage of cell fill ranged from 103.5 to 113.3 % in the best operational conditions; the seed metering accuracy reached at outlet of the seed tube, expressed as acceptable time, was 34.5%; both the level of seeds in the hopper and the lateral inclination of the seed meter did not statistically affect the accuracy and, finally, the prototype caused mechanical injuries to of the seeds of the order of 3.5 %.

Guler (2011) in his study determined the optimum dimensions of flute diameter and helical angle of fluted roller used in seed drills for lentil seeds at 100 kg ha^{-1} of seed rate. The values of coefficient variation were used to determine the optimum dimensions of fluted rollers. The best rates of flow evenness and the minimum coefficient of variance values were obtained at the flute diameter of 8 and 10 mm, helical angle of 10 and 20 degrees (°).

2.5 Transplanters for Vegetable Crops

Hernandez and Morales (1996) evaluated a mechanical transplanter for transplanting Chinese cabbage seedlings in loam soil at moisture content of 18-30%. Results showed that out of total seedlings transplanted, 18.4 % remained well placed, 37.1% remained inclined and 44.5 % remained unplanted.

Chaudhari *et al.* (2001) studied the adaptability trials of two row mechanical transplanter for vegetable seedlings. Result showed that missing hills and plants in lying down positions ranged from 3.70 to 6.67 % and 7.28 to 11.0 % respectively.

Garg and Dixit (2002) designed, developed and evaluated a tractor operated single row vegetable transplanter. The machine was tested at an average speed of 1.35 km h^{-1} for transplanting chilli and brinjal seedlings, having height of 20.4 to 21.4 cm. The average plant missing was about 14.8 % for chilli and 15.7 % for brinjal. The average plant mortality after 15 days of transplanting was found to be 12 % for both crops.

Chaudhari *et al.* (2003) reported the design and development of two row semi-automatic transplanter. The machine was operated at a speed of 0.7 to 1.0 km h^{-1} depending on the plant spacing and feeding ability of the operator. Performance evaluation of the transplanter was carried out for transplanting tomato, brinjal, cabbage and cauliflower. The field capacity ranged from 0.08 to 0.10 ha h^{-1}. Missing hills ranged from 2.85 to 9.33 % and percentage of seedlings in lying down position ranged from 7.69 to 13.43 %.The machine was evaluated for transplanting of tomato and chilly crops. They also evaluated the three row machine having field capacity of 0.10-0.15 ha h^{-1}. The missing hills ranged from 2.60-5.65% depending upon skill and training of operator. Labour requirement for manual transplanting ranged from 243.90-312.5 man-h ha^{-1} as compared to 26 to 40 man-h ha^{-1} required for machine transplanting.

Mandar and Corlin (2003) developed tractor operated 2-3 row vegetable transplanter, which could be used for cabbage, cauliflower, etc. It was reported that the capacity of the plug type transplanter was 60 plants per minute per row and the established crop stand was found better than manual transplanting.

Satpathy (2003) conducted studies on a two row semi-automatic vegetable transplanter having finger type metering mechanism for bare-root seedlings. Plants missing in case of tomato and chilli crop were 6.19 and 1.67 %, respectively at machine speed of 1.0 km h^{-1}. Seedling age of 5 weeks in case of tomato and 17 to 19 weeks for chilli was reported for better performance of the machine.

Anonymous (2004a), reviewed that a tractor mounted semi-automatic three-row plug type vegetable transplanter was developed at TNAU, Coimbatore. The machine worked on the principle of dropping-potted plants from a certain height to the ground. The impact of the seedling with soil blocks helped in its placement. The unit consisted of main frame with hitching system, ground wheel, shoe type furrow openers, compaction wheel, operator's seat, plug type metering mechanism and two depth control wheels. The machine of 350 kg weight could be operated using 45 hp tractors. It employed press wheels inclined at an angle of 15° with the vertical as soil covering device. The machine could be operated with 1.4 km h^{-1} forward speed. It was economically viable in places where labour wages were more than Rs. 60 per day. The field capacity of the transplanter was 0.140 ha h^{-1} with field efficiency of 75 % for transplanting chilli, brinjal and tomato with 450 mm row spacing.

Anonymous (2009) reviewed a tractor drawn semi automatic onion transplanter developed by Pandharinath Sarjerao More, a farmer of Ahmednagar, Maharashtra, consisting of cultivator frame, furrow opener, fertilizer drilling unit, feeding chute seedlings, seedlings tray, two ground wheels with gear connected to fertilizer drill through chain and sprockets and seating arrangement for four persons, etc. When the tractor moved forward, the fertilizer metering mechanism got the drive to release the fertilizer in the tubes. The seedlings (50 days age nursery) were delivered manually to the delivery chutes at the regular intervals. The seedling hoppers were connected with fertilizer drilling tubes at bottom, so that precise amount of fertilizers could be drilled alongwith seedlings while planting. A channel forming ridger plough was mounted offset to the right end of the transplanter to form the irrigation channel simultaneously.

Turbatmath (2011) developed a tractor operated semi-automatic onion transplanter. The results of field trials of the machine revealed that the missing percentage was 5.0 – 5.7, the capacity of machine was 0.077 – 0.09 ha h^{-1} with field efficiency of 70.5 – 71.60 % and the draft of machine was in the range of 450 – 470 kgf. The saving in cost of operation over manual transplanting was 38.84 %.

3. MATERIAL AND METHODS

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

1. It should consist of proper metering device to maintain the desired crop geometry and plant population.

   For *kharif* and late *kharif* season: 15 x 10 cm (plant population per ha: 6,66,000)

   For *rabi* season: 12.5 x 7.5 cm (plant population per ha: 10,66,400) (*Krishi Darshani, 2009*).
2. It should place the seed at desired depth.

   For direct sowing onion seed, the depth varies from 2.5 – 3 cm, (*Technical Bulletin, NHRDF, 2004*).
3. There should be provision for row spacing adjustments.
4. The weight of the machine should be within the pushing power of the human kind.

   For 3-4 hours continuous work and 0.8 ms^{-1} operating speed of machine, an average man can develop about 10.5 kgf force *(Sharma and Mukesh, 2008).*
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 should be minimum from ground to avoid bouncing of seed.

Keeping in view all the above points, the onion seed planter was developed in the Department of Farm Machinery and Power, Dr. Annasaheb Shinde College of Agricultural Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri, District-Ahmednagar (Maharashtra State) in the year 2011-12.

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 onion seed planter
2. Working mechanism
3. Test procedure
4. Instrumentation

3.1 Functional Units of Manually Operated Onion Seed planter:

The manually operated onion seed planter consisted of the following functional units:

1. Main frame
2. Furrow opener
3. Power transmission unit
4. Seed metering unit
5. Seed collecting unit
6. Supporting wheel

3.1.1 Main Frame

The main frame assembly was made of 25 mm square m.s. pipe. It could support seed box and furrow openers. The seed box was mounted on main frame with support. The main frame assembly with attached handle is shown in Fig.3.4 and 3.5, with detailed dimensions.

3.1.2 Furrow Opener

The furrow openers (Fig.3.6) were 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 the nut and bolt arrangement. The standard of furrow opener was made of m.s. square rod of size 9.0 x 9.0 mm and lower end of the standard was hot forged and was having a bend, forming an obtuse angle with the soil.

3.1.3 Power Transmission Unit

The power transmission unit consisted of the following components:

1. Ground wheel,
2. Ground wheel shaft,
3. Chain and sprockets arrangement.

3.1.3.1 Ground Wheel

Two ground wheels were provided on the front side of the main frame, which formed the functional component of power transmission unit (Fig.3.7). The rotation of ground wheel caused the rotation of seed rotor through chain and sprocket arrangement. Ground wheel was made up of m.s. flat of thickness 5 mm and width 30 mm. The effective diameter of ground wheel was 250 mm. There were 16 lugs with 10 mm width and 5 mm thickness provided to avoid the slippage. A sprocket was mounted on the ground wheel to transmit power from ground wheel to rotor shaft with the help of chain.

3.1.3.2 Ground Wheel Shaft

The ground wheel shaft was attached to the main frame with nuts and bolts. The shaft was made of m.s. bright bar of 19 mm diameter and 520 mm in length. The ground wheel shaft is shown in Fig. 3.8.

3.1.3.3 Chain and Sprockets Arrangement

The seed rotor was mounted on the rotor shaft. The shaft received power from ground wheel through the chain and sprockets arrangement. The driving sprocket was mounted on ground wheel and the driven on rotor shaft. The pitch diameter of the sprockets was 12.7 mm. The sprocket A and B had 16 and 20 teeth respectively; and sprockets C had 18 teeth each. Suitable chain was used to connect the two sprockets. The detailed drawing of chain and sprocket is shown in Fig.3.9.

Table 3.1 Arrangement of sprockets for different crop geometry

Crop Geometry	Sprocket on Ground Wheel	Sprocket on rotor shaft
15 X 10 cm	B	A
12.5 X 7.5 cm	C	C

3.1.4 Seed Metering Unit

The seed metering unit consisted of following components:

1. Seed box,
2. Auxiliary seed box,
3. Seed metering mechanism,
4. Rotor shaft.

3.1.4.1 Seed Box

The onion seed planter was provided with a seed box as shown in Fig.3.10. The seed box was semi-circular in shape at bottom. This seed box was divided into three compartments to place the onion seeds as close as possible to the seed rotor. The total carrying capacity of each compartment was 70 g of onion seed. The detailed dimensions of seed box are shown in Fig. 3.11. The seed box 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.

3.1.4.2 Auxiliary Seed Box

As the carrying capacity of main seed box was very low, an additional seed box was provided to the onion seed planter. This auxiliary seed box (Fig.3.13) was placed above the main seed box to allow the free fall of onion seeds with gravity into the main seed box. The carrying capacity of auxiliary seed box was 450 g. It was made from m.s. sheet of thickness 1.6 mm.

3.1.4.3 Seed Metering Mechanism

Considering the various physical properties of onion seeds (Appendix I), the cup feed type metering mechanism was selected for manually operated onion seed planter. The seed rotor was made of m.s. flat of 5 mm thickness with diameter as 90 mm (Fig.3.14). There were three seed rotors, which were spaced with the help of spacers (Fig.3.15). The seed rotors rotated in the seed rotor box with the help of rotor shaft. The rotor had the square hole for mounting it on rotor shaft, which was having square cross section at the mid-length, so that there was no need to have a key and key-way arrangement for the seed rotor and rotor shaft. The number of cells on seed rotor was calculated by the following formula as given by *Sharma and Mukesh*, *2008*:

$$n = \frac{\pi \ D}{i \ x}$$

Where,

n = number of cells on rotor,

D = ground wheel diameter, cm

x = required seed to seed spacing, cm

i = gear ratio (no. of teeth on rotor shaft sprocket / no. teeth on ground wheel sprocket).

3.1.4.4 Rotor Shaft

The rotor shaft of 16 x 16 mm was made of m.s. bright bar (Fig.3.16). The length of the shaft was 400 mm and was having a square cross section at the middle of the length. The remaining two sides were made of round section of 17 mm diameter so that the shaft could be supported in two bush bearings of 17 mm size having 25.4 mm length each.

3.1.5 Seed Collecting Unit

There was an arrangement for collecting seeds from seed rotors (Fig.3.17). As the seed rotors rotated with the rotor shaft, they collected the onion seeds from seed box and dropped the seeds into seed collecting funnel. The seed tubes were attached at the bottom of funnels, which carried the seeds from funnel to the bottom of furrow openers. The funnels were made of plastic material.

3.1.6 Supporting Wheel

There was an arrangement of supporting wheel (Fig.3.18) at the back side of onion seed planter to support and balance the weight of planter. The supporting wheel was made up of 5 mm thick m.s. flat with 30 mm as width and effective diameter was 250 mm. The supporting wheel was mounted on a shaft of length 325 mm and 18 mm diameter with two bush bearings.

3.2 Working Mechanism

As the equipment was operated in the field, the ground wheel being in contact with the soil, rotated at uniform speed. As the ground wheel rotated, the driving sprocket mounted on it also rotated. The driving sprocket transmitted power with rotary motion to the driven sprocket with the help of chain, which was mounted on the rotor shaft. Motion of the driven sprocket caused the motion of rotor shaft, which rotated the seed rotor. The seed rotor picked up seeds from the seed box in the cells and dropped them into the collecting hopper. From collecting hopper seeds were transferred to the furrow openers through the seed tubes at recommended spacing.

3.3 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 of any farm machine / implement:

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

3.3.1 General Test

3.3.1.1 Checking of Specifications

After development of the onion seed planter, all the specifications of the components were checked for their accuracy.

3.3.1.2 Checking of Material

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

3.3.1.3 Visual Observations and Provision for Adjustment

The onion seed planter was visually observed and necessary adjustments were made in the planter.

3.3.2 Laboratory Test

3.3.2.1 Seed Metering Test

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

3.3.2.1.1 Calibration Procedure

1. The onion seed planter was set on flat and levelled surface. Bricks were placed under the frame so that the ground wheels could be rotated freely.
2. The plastic bowls were placed below the 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.

3.3.2.2 Seed Damage Determination Test

It was used to determine any mechanical damage caused 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:

$$\text{Damaged seeds percentage} = \frac{\text{Damaged seeds}}{\text{Total seeds for hopper f illing}} \text{x } 100$$

3.3.3 Field Test

The testing of the developed equipment for onion seed planting was conducted on the farm of AICRP on Vegetable Crops, MPKV, Rahuri. This trial was conducted in field of 0.1 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:

3.3.3.1. Variety

The variety sown during field trail was noted.

3.3.3.2 Plot Size

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

3.3.3.3 Soil Moisture Content

The soil samples were taken from five places randomly on the field. The oven drying method was used to determine the moisture content. The samples were kept in the sample boxes and weighed. After weighing, the sample boxes were kept in thermostatically controlled oven at 150^{o} C temperature for 24 hours in the laboratory of Dr. A.S.C.A.E., MPKV, Rahuri. After 24 hours of drying, the sample boxes were taken from the oven and kept in desiccators to let them cool for few minutes. After cooling, the weights of oven dried samples were taken. The moisture content on 'wet' basis was calculated by using following formula:

$$W = \frac{W2 - W3}{W2 - W1}\, X\ 100$$

Where,

W = Moisture content of soil, % (w.b.)

W1 = Weight of container + lid, g

W2 = Weight of container + lid + wet soil, g

W3 = Weight of container + lid + dry soil, g

3.3.3.4 Number of Furrow Openers

The numbers of furrow openers were recorded as three.

3.3.3.5 Recommended Crop Geometry

The recommended crop geometry for onion was 15 cm row to row spacing and 10 cm plant to plant spacing for kharif season.

3.3.3.6 Obtained Crop Geometry

The crop geometry obtained after sowing was measured with the help of tape and was recorded.

3.3.3.7 Depth of Seed Placement

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

3.3.3.8 Seed Rate Obtained

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

3.3.3.9 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.

3.3.3.10 Theoretical Field Capacity

The theoretical field capacity was calculated by following formula:

$$\text{Theoretical field capacity, ha/h} = \frac{\text{Width, m x Speed, mph}}{10000}$$

3.3.3.11 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 kmh^{-1}.

3.3.3.12 Actual Operating Hours

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

3.3.3.13 Effective Field Capacity

The effective field capacity is the actual area covered by the implement, based on its total time required and its width. It was calculated by following formula:

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

3.3.3.14 Field Efficiency

The field efficiency was calculated by following formula:

$$\text{Field efficiency} = \frac{\text{Effective field capacity, ha/h}}{\text{Theoretical field capacity, ha/h}}$$

3.3.3.15 Man-Hours Requirement

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

3.4 Instrumentation

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

3.4.1 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.

3.4.2 Vernier Caliper, Steel Tape, 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.

3.4.3 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 while conducting the calibration test.

3.4.4 Electrical oven

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

3.4.5 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 the newly developed manually operated onion seed planter. Tests were conducted in both, laboratory and field. The laboratory tests were conducted in Workshop Technology Laboratory (College Workshop), Dr. A. S. C. A. E., MPKV, Rahuri, while the field tests were conducted on the farm of AICRP on Vegetables Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri. The onion seeds of variety “Phule Samarth” were 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, Dr. A.S.C.A.E. MPKV, Rahuri:

4.1.1 Calibration Test

The manually operated onion seed planter was calibrated for determining the seed rate of the machine. Standard calibration procedure was followed as discussed in the chapter ‘Materials and Methods’. The test data of the machine are given in the Table 4.1 and 4.2 for seed distribution.

Table 4.1 Calibration test data of manually operated onion seed planter

1.	Date	15.06.2012
2.	Place	Workshop Technology Laboratory (College Workshop)
3.	Working width of machine (m)	0.45
4.	Length of strip to cover one hectare area (m)	22222.22
5.	Diameter of ground wheel (m)	0.25
6.	Number of revolutions of ground wheel to cover the length obtained in (4)	28294
7.	Number of revolutions of ground wheel to cover 1/1000 ha	28.294
8	Area covered in 10 revolutions (m^2)	3.53
9	Revolutions per minute of ground wheel at speed of 2.4 km/h (rpm)	50.93
10	a. Kind of seed	Onion
	b. Variety	Phule Samarth
	c. Weight of 1000 seed (g)	2.98

For calibration of the machine, total three replications were taken, in which weight of seeds collected from each furrow opener varied from 0.00064 kg to 0.00070 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 5.66 kg ha^{-1}.

Table 4.2 Calibration of onion seed planter by giving 10 revolutions to the ground wheel

Replication no.	Furrow opener no.	Weight of seed collected at each furrow opener (kg)	Weight of seed collected from all furrow opener (kg)	Calculated seed rate from all furrow opener (kg ha^{-1})	Average seed rate (kg ha^{-1})
I	1	0.00066	0.0020	5.67	5.66
	2	0.00070			
	3	0.00064			
II	1	0.00065	0.0019	5.40	
	2	0.00068			
	3	0.00066			
III	1	0.00064	0.0021	5.90	
	2	0.00069			
	3	0.00068			

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.

It was observed from the table 4.3 that the seed damage percentage is zero. There is no damage to onion seeds due to the seed metering device.

Table 4.3 Damage caused to the seeds during calibration

Replication	Furrow opener	Seed damaged before passing seed metering device (%)	Seed damaged after passing the seed metering device (%)	Average seed damage (%)	Total average seed damaged (%)
I	1	0	0	0	0
	2	0	0		
	3	0	0		
II	1	0	0	0	0
	2	0	0		
	3	0	0		
III	1	0	0	0	0
	2	0	0		
	3	0	0		

4.2 Field Test

The onion seed planter was tested in the field for evaluating the field performance. Field test was conducted by using onion seed of variety "Phule Samarth". 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 onion seed planter was tested for its performance under the conditions given in table 4.4. The performance test data were analyzed and the final test results are tabulated in table 4.5.

Table 4.4 Test conditions for performance evaluation of manually operated onion seed planter

Sr. no.	Particular	Values
1.	**General**	
	Date of test	20.07.2012
	Location of test	Farm of AICRP on Vegetable Crops, MPKV, Rahuri.
2.	**Field parameters**	
	Type of soil	Medium black
	Soil moisture content, % (w.b.)	18.53
	Plot size, m^2	50 x 20
3.	**Machine parameter**	
	Name of implement	Manually operated onion seed planter
	No. of furrow openers	Three
	Weight of machine, kg	20.5
4.	**Seed parameter**	
	Name of seed	Onion
	Variety of seed	Phule Samarth
	Germination percentage (min.)	70
	Max. moisture, % (w.b.)	12
	Av. Weight of 1000 grain, g	2.98
	Geometric mean diameter, mm	2.018
	Sphericity	0.693
	Angle of repose, (˚degree)	25.18
5.	Labor requirement	One

4.2.1 Variety

The variety sown during field trail was “Phule Samarth”.

4.2.2 Plot Size

Dimensions of the field were 50 m x 20 m.

4.2.3 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 was found to be 18.53% on wet basis (Appendix II).

4.2.4 Number of Furrow Openers

The numbers of furrow openers was three.

4.2.5 Recommended Crop Geometry

The recommended crop geometry for onion was 15 cm row to row spacing and 10 cm plant to plant spacing for kharif season.

4.2.6 Obtained Crop Geometry

The crop geometry obtained was 15 cm row to row spacing and 9.96 cm plant to plant spacing (Appendix III).

4.2.7 Depth of Seed Placement

The depth of seed placement varied from 2.1 to 2.6 cm. The average depth of seed placement was observed to be 2.38 cm. Depth was measured using meter rule. For this, five random observations were taken and average was calculated (Appendix IV).

4.2.8 Seed Rate Obtained

The total weight of the seeds used for plantation on the selected field plot was 750 g. Thus the average seed rate was found to be 7.5 kg ha^{-1} for onion.

4.2.9 Plant Population per Hectare

The average plant population was observed to be 6, 70,000 plants per hectare.

4.2.10 Theoretical Field Capacity

The theoretical field capacity was found to be 0.108 ha h^{-1} (Appendix VI).

4.2.11 Actual Average Travelling Speed

The actual average travelling speed was about 2.4 km h^{-1}.

4.2.12 Actual Operating Hours

The total area covered during the functional field test was 0.1 ha and the duration of test was 1.11 h.

4.2.13 Effective Field Capacity

The effective capacity was found to be 0.09 ha h^{-1} (Appendix VI).

4.2.14 Field Efficiency

The field efficiency was calculated by the formula given in the previous chapter, 'Material and Methods'. The field efficiency of the onion seed planter was found to be 83.33 % (Appendix VI).

4.2.15 Man-Hours Requirement

The man hours required to complete the operation were found to be 11.1 for one ha.

Table 4.5 Results of the field tests of manually operated onion seed planter

Sr. no.	Particular	Value
1.	Variety	Phule Samarth
2.	Plot size, m^2	50 x 20
3.	Soil moisture content, % wb	18.53
4.	No. of furrow openers	3
5.	Recommended crop geometry, cm	15 × 10
6.	Obtained crop geometry, cm	15 × 9.96
7.	Average depth of seed placement, cm	2.38
8.	Seed rate obtained, kg ha^{-1}	7.50
9.	Plant population per hectare	6,70,000
10.	Theoretical field capacity, ha h^{-1}	0.108
11.	Actual average travelling speed, km h^{-1}	2.4
12.	Duration of the test, h	1.11
13.	Effective field capacity, ha h^{-1}	0.09
14.	Field efficiency, %	83.33
15.	Man hours requirement	11.1
16.	Cost of operation, Rs./ha	368

5. SUMMARY AND CONCLUSION

5.1 Summary

Agriculture occupies an important position in India as it contributed nearly 14.6% of the GDP in 2009-10 and provided employment to 52 % of country's work force. Also one important emerging feature of Indian agriculture is the increasing number of marginal and small size holdings. So, India's food security largely depends on these farmers. Hence it is the need of time to make a technology according to their need and in such a way that they could afford it.

Vegetables are considered protective foods and also play an important role in providing a balanced diet to human beings. They are short duration and therefore, more number of crops can be grown per year. Owing to shrinkage of agricultural land due to urbanization and industrialization, cultivation of vegetable crops will be more economical. Onion (*Allium cepa L.*) is one of the most important vegetable crops grown throughout the country. It is widely grown in different parts of the country mainly by small and marginal farmers. Generally, the onion seeds are sown in nursery and then transplanted. Also, it is grown by direct seeding the seeds in plot. In the method of direct seeding generally seeds are broadcast in the field, and hence the proper plant geometry is not maintained in this method. Keeping these problems in mind it was decided to develop a manually operated onion seed planter with the following objectives:

1. To develop a manually operated onion seed planter.
2. To conduct functional trials of the manually operated onion seed planter.

The machine had five main components namely: main frame, furrow openers, power transmission unit, seed metering unit and supporting wheel. The seed rotor was made up of m.s. flat of 5 mm thickness with diameter as 90 mm. The cups on the plate were drilled with 3.5 mm size drill upto a depth of 5 mm at an angle 45^o with vertical line. As the equipment was operated in the field, the ground wheel being in contact with the soil, rotated at uniform speed. There was chain and sprocket arrangement for power transmission from ground wheel to seed rotor. So, as the ground wheel rotated, the seed rotor also rotated. With these rotations, the seed rotor picked up the seeds from seed box in the cells and droped them into the collecting hopper. From collecting hopper seeds were transferred to furrow opener through the seed tube at recommended spacing.

The seed planter was tested in both laboratory and field by using onion seeds of variety “Phule Samarth”. The onion seed planter was tested in laboratory for the calibration and to know the seed damage. The onion seed planter was tested in field in 0.1 hectare area. Field test was conducted at the forward speed of 2.0 km h^{-1}. The field trials of the developed seed planter indicated that it could perform the intended functions satisfactorily with an average field efficiency of 83.33 % and the field capacity of 0.09 ha h^{-1}.

5.2 Conclusions

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

1. The machine could be used for direct seeding of onion seeds at desired row to row and plant to plant spacing and desired depth of the sowing.
2. The performance of seed metering device was satisfactory. It gave seed rate 7.50 kg ha^{-1} as against the recommended seed rate of 8-10 kg ha^{-1} during the field trials and seed damage was zero.
3. The average achieved plant geometry was 15 × 9.96 cm against the recommended plant geometry of 15 × 10 cm and average depth of sowing was 2.38 cm.
4. Plant population was found to be 6,70,000 per hectare as against the recommended plant population of 6,66,000 per hectare.
5. The actual field capacity was found to be 0.09 ha h^{-1}.
6. The average field efficiency of the machine was 83.33 %.
7. The overall weight of the machine was 20.5 kg.
8. The operating cost of the machine was Rs.368 per hectare.

6. SUGESSIONS FOR FUTURE WORK

In view of making this manually operated onion seed 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 varieties of onion crop need to be conducted to check the performance of the seed planter for different varieties of onion.
2. The seed box should be designed in such a manner so that the seeds remained after seeding could be removed easily without any damage.
3. The handle should be made adjustable so that it could suit to different heights of operator.
4. The seed metering device should be used for bullock drawn and tractor operated planter.

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8. APPENDICES

APPENDIX - I

Physical Properties of Onion Seeds

Observations	Length (l), mm	Breadth (b), mm	Thickness (t), mm	Geometric mean diameter $\sqrt[3]{(l \times b \times t)}$, mm	Sphericity $\frac{\sqrt[3]{l \times b \times t}}{l}$
1.	2.80	1.97	1.42	1.986	0.710
2.	3.00	2.00	1.50	2.080	0.693
3.	2.92	1.90	1.39	1.976	0.677
4.	2.98	1.95	1.43	2.025	0.680
5.	2.89	1.98	1.45	2.024	0.700
6.	3.10	1.97	1.48	2.083	0.672
7.	2.88	1.89	1.42	1.977	0.686
8.	2.90	1.94	1.40	1.990	0.686
9.	2.85	1.96	1.46	2.013	0.706
10.	2.80	1.99	1.49	2.025	0.723
Average	**2.912**	**1.955**	**1.444**	**2.018**	**0.693**

APPENDIX – II

Moisture Content

Sr. No.	Weight of container + lid (W1), g	Weight of container + lid + wet soil (W2), g	Weight of container + lid + dry soil (W3), g	Moisture content, % (w.b.)
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**

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

Average moisture content = 18.53 % (w.b.)

APPENDIX - III

Plant geometry

Plant to plant distance, cm

Sr. No.	Observation, cm
1.	9.95
2.	9.89
3.	10.00
4.	9.98
5.	9.90
6.	9.97
7.	10.01
8.	10.00
9.	9.96
10.	9.98
Average	**9.96**

Plant geometry = 15 x 9.96 cm

APPENDIX - IV

Depth of seed placement

Sr. No.	Observation, cm
1.	2.5
2.	2.3
3.	2.1
4.	2.6
5.	2.4
Average	**2.38**

Average depth of seed placement = 2.38 cm

APPENDIX – V

Plant population per square meter

Sr. No.	Observations
1.	67
2.	68
3.	66
4.	68
5.	66
Average	**67**

APPENDIX – VI

Field Efficiency, %

1. Theoretical field capacity (ha/h)

The theoretical field capacity was calculated by following formula:

$$\text{Theoretical field capacity, ha/h } = \frac{\text{Width, m x Speed, mph}}{10000}$$

$$\text{Theoretical field capacity, ha/h } = \frac{0.45 \ \times 2400}{10000}$$

Theoretical field capacity, ha/h = 0.108 ha/h

2. Effective field capacity (ha/h)

The effective field capacity is calculated by following formula:

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

$$\text{Effective field capacity, ha/h} = \frac{0.1}{1.11}$$

Effective field capacity, ha/h = 0.09 ha/h

3. Field efficiency (%)

The field efficiency was calculated by following formula:

$$\text{Field efficiency} = \frac{\text{Effective field capacity, ha/h}}{\text{Theoretical field capacity, ha/h}}$$

$$\text{Field efficiency, \%} = \frac{0.09}{0.108} \times 100$$

Field efficiency, % = 83.33

APPENDIX – VII

Cost of operation per hectare of manually operated onion seed planter

A. Fixed per hectare

It was calculated as follows:

1. Depreciation per hour

It is loss of value of onion seed 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 2940)

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)

$$D = \frac{2940 - 294}{10 \times 300}$$

$$D = 0.882$$

Depreciation per hour = Rs. 0.882

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 formula:

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

Where,

I = Interest to be paid per hour

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

$$I = \frac{2940 + 294}{2} \times \frac{10}{100 \times 300}$$

$$I = 0.539$$

Interest per hour = Rs. 0.539

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)

$$H = \frac{2940}{300} \times \frac{1}{100}$$
$$H = 0.098$$

Housing cost per hour = Rs. 0.098

4. **Insurance**

   Insurance charges were taken as nil.

5. **Taxes**

   Not applicable hence, it was taken as nil.

Fixed cost per hour = Rs. 1.519

B. **Variable cost per hour**

   It includes total of following costs.

1. **Fuel cost per hour**

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

2. **Lubricant cost per hour**

   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:

$$\text{Repair and maintenance cost per hour} = \frac{7 \times \mathrm{P}}{100 \times \mathrm{h}}$$
$$\text{Repair and maintenance cost per hour} = \frac{7 \times 2940}{100 \times 300}$$

Repair and maintenance cost per hour = Rs. 0.686

4. **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. 25.686

C. Total cost (A + B)

Total cost of operation of manually operated onion seed planter was calculated in Rs. per hour by adding A and B above.

Total cost = fixed cost per hour +variable cost per hour

Total cost = 1.519 + 25.686

Total cost per hour = Rs. 27.205

D. Cost of operation per hectare

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

$$\text{Cost of operation of planter (Rs./ha)} = \frac{\text{Cost of operation of planter (Rs./h)}}{\text{Field capacity of planter (ha/h)}}$$

$$\text{Cost of operation of planter (Rs./ha)} = \frac{27.205}{0.074}$$

$$\text{Cost of operation of planter (Rs./ha)} = 367.64$$

Cost of operation per hectare of onion seed planter = Rs. 368

APPENDIX – VIII

Specifications of the manually operated onion seed planter

Sr. No.	Particulars	Specifications
1.	**General**	
	Name	Manually operated onion seed planter
	Major function	Sowing onion seeds at proper spacing and depth
2.	**Furrow opener**	
	No. of furrow openers	3
	Depth control adjustment	Using nuts and bolts arrangement
3.	**Metering unit**	
	Seed metering mechanism	Cup feed type
	Method of changing seed spacing	By changing gear ratio
	Material	Mild Steel
4.	**Ground wheel**	
	No.	2
	Type of wheel	Wheel with spikes
	Material	Mild steel
5.	**Power transmission**	Through chain and sprockets
6.	**Overall dimensions**	
	Length, mm	1072.6
	Width, mm	592.1
	Height, mm	966.1
	Weight, kg	20.5

APPENDIX – IX

Details of costs of fabrication of manually operated onion seed planter

Sr. No.	Description	Quantity	Rate	Cost (Rs.)
1.	MS square pipe, size 25 x 25 x 3 mm	5.02 kg	Rs. 55 / kg	276.10
2.	MS round pipe, size 25 x 3 mm	5.40 kg	Rs. 55 / kg	297.00
3.	MS bright bar, size 400 x 16 x 16 mm	0.80 kg	Rs. 80 / kg	64.00
4.	MS square bar, size 10 x 10 mm	0.45 kg	Rs. 48 / kg	216.00
5.	MS shaft, Φ 20 mm	3. 0 kg	Rs. 80 / kg	240.00
6.	Ball Bearing, No.6203ZZ, size I.D. 16 mm	2 Nos.	Rs. 50 / pc.	100.00
7.	Sprocket, size 18 teeth, 12.7mm pitch	2 Nos.	Rs. 40 / pc	80.00
8.	Sprocket, size 16 teeth, 12.7 mm pitch	1 Nos.	Rs. 75 / pc	75.00
9.	Sprocket, size 20 teeth, 12.7 mm pitch	1 Nos.	Rs. 85 /pc	85.00
10.	MS flat, size 30 x 5 mm	4.5 kg	Rs. 48 / kg	216.00
11.	MS flat, size 100 x 100 x 5 mm	1 kg	Rs. 48 / kg	48.00
12.	Bicycle chain, standard	1 Nos.	Rs. 50 / kg	50.00
13.	Miscellaneous (nuts, bolts, washers)	0.40 kg	Rs. 80 / kg	32.00
14.	Welding rods	1 packet	Rs. 230 /packet	230.00
15.	Color	1 lit	Rs.200/lit	200.00
16.	MS sheet, thickness 1.25 mm, 1m^2	2.0 kg	Rs. 55 / kg	110.00
17.	Seed tube pipe, 1 inch	6 ft.	Rs. 5 / ft.	30.00
18.	Cost of fabrications (25 % of cost of above material)	-	-	587.275
	Total cost			Rs. 2936.375
	i.e.			**Rs. 2940**

9. VITA

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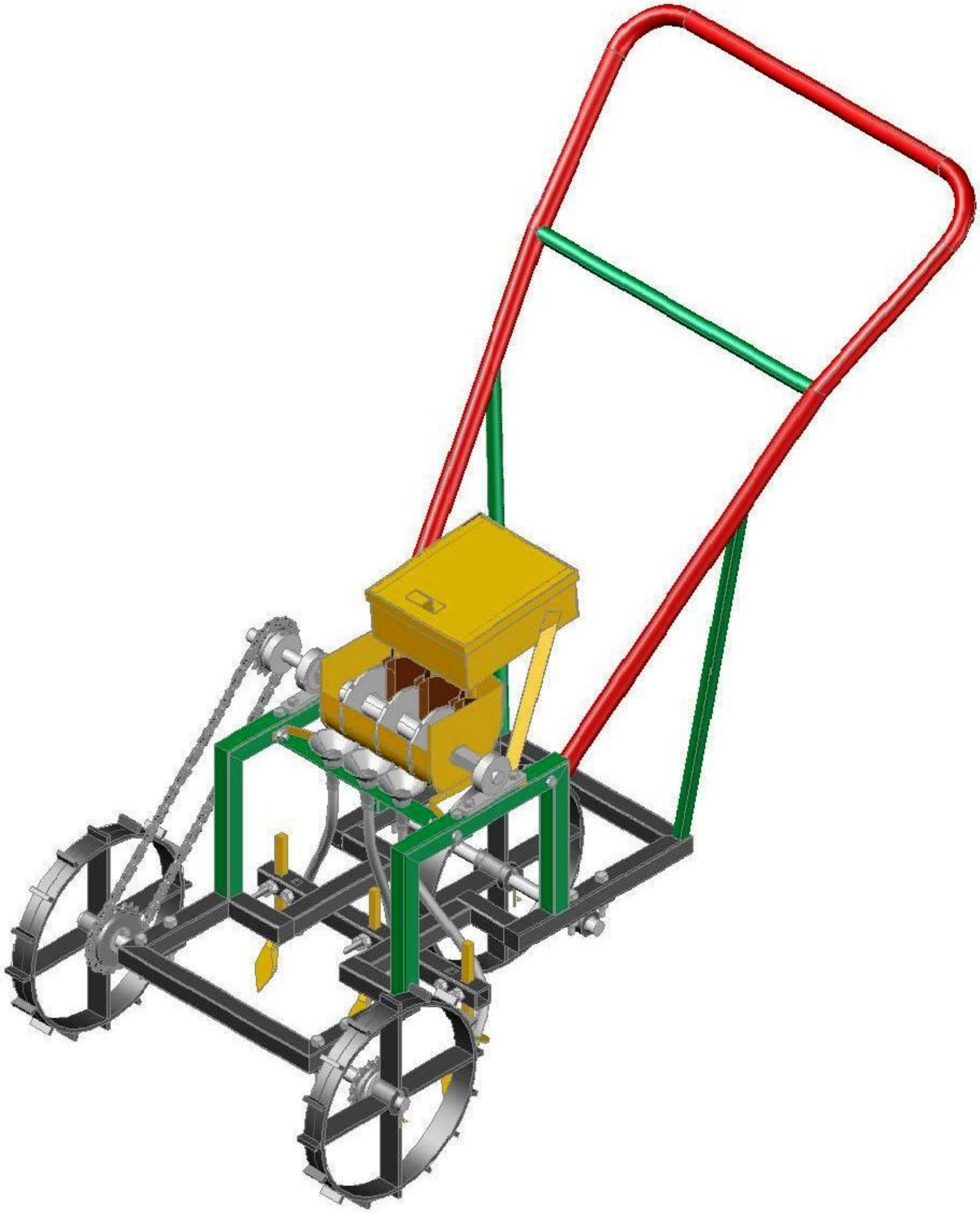


Fig. 3.1 Three Dimensional View of Manually Operated Onion Seed Planter

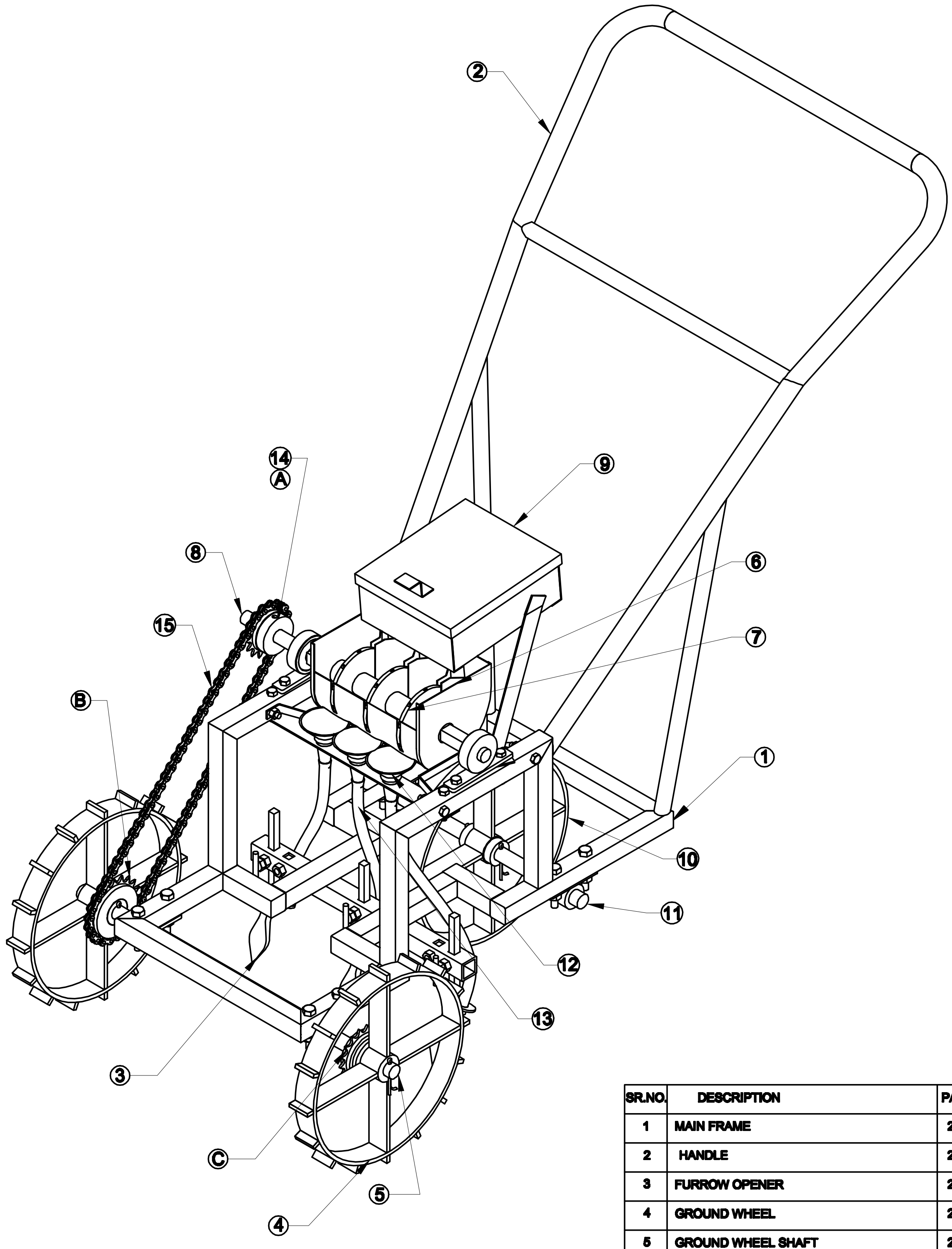


Fig. 3.2 ISOMETRIC VIEW OF MANUALLY OPERATED ONION SEED PLANTER

SR.NO.	DESCRIPTION	PART NO	QTY	
1	MAIN FRAME	2:1	01	
2	HANDLE	2:2	01	
3	FURROW OPENER	2:3	03	
4	GROUND WHEEL	2:4	01	
5	GROUND WHEEL SHAFT	2:5	01	
6	SEED BOX	2:6	01	
7	SEED ROTOR	2:7	03	
8	SEED ROTOR SHAFT	2:8	01	
9	AUXILLARY SEED BOX	2:9	01	
10	SUPPORTING WHEEL	2:10	01	
11	SUPPORTING WHEEL SHAFT	2:11	01	
12	FUNNEL	2:12	03	
13	SEED TUBE	2:13	03	
14	SPROCKET - A	2:14	01	
	SPROCKET - B		01	
	SPROCKET - C		02	
15	CHAIN	2:17	01	

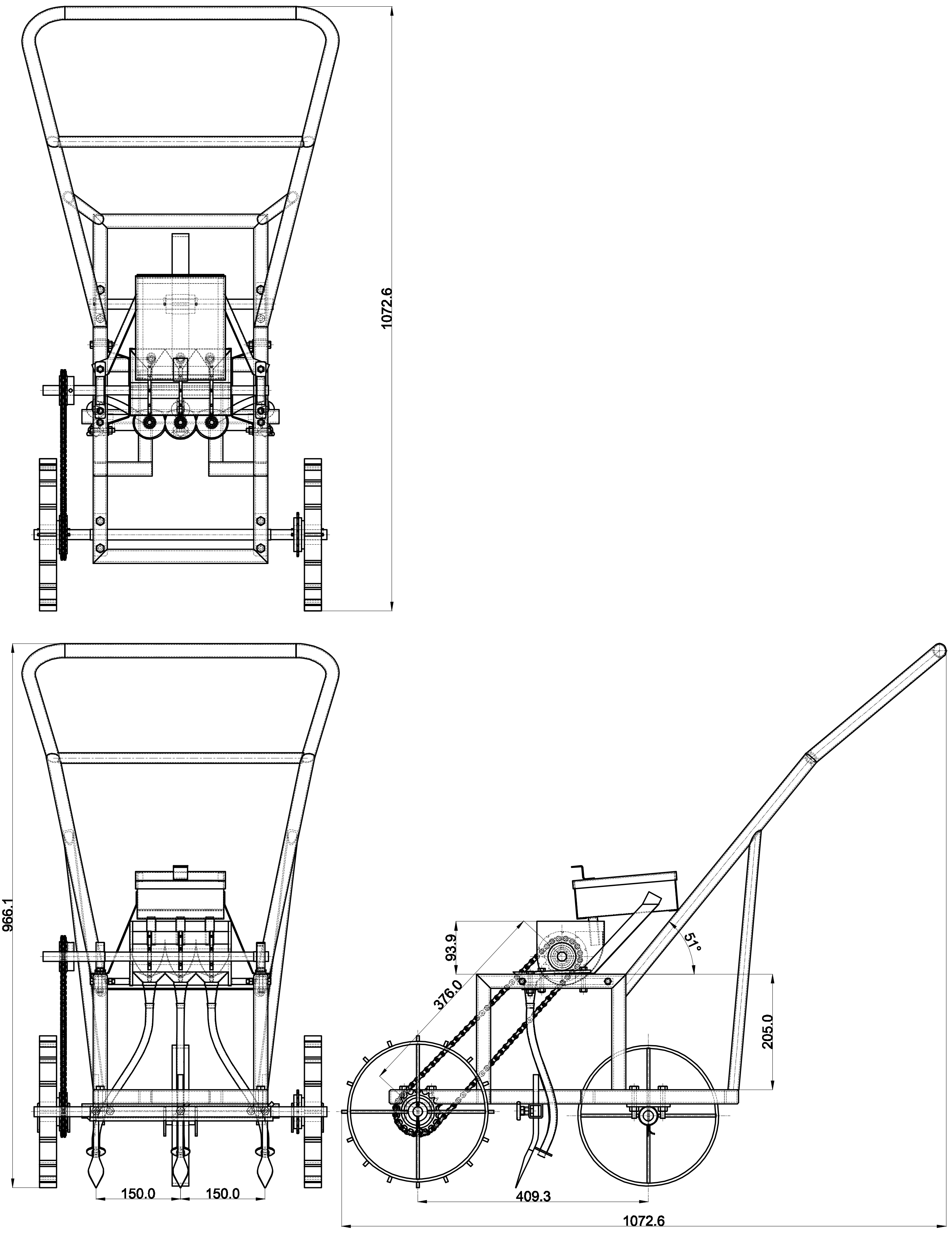


Fig. 3.3 ORTHOGRAPHIC VIEW OF MANUALLY OPERATED ONION SEED PLANTER

NOTES	SCALE	SYMBOL
1. All DIMENSIONS ARE IN MM.		
2. ALL JOINTS ARE FULL WELDED	SCALE	SYMBOL
3. REMOVE ALL SHARP CORNER	NTS	

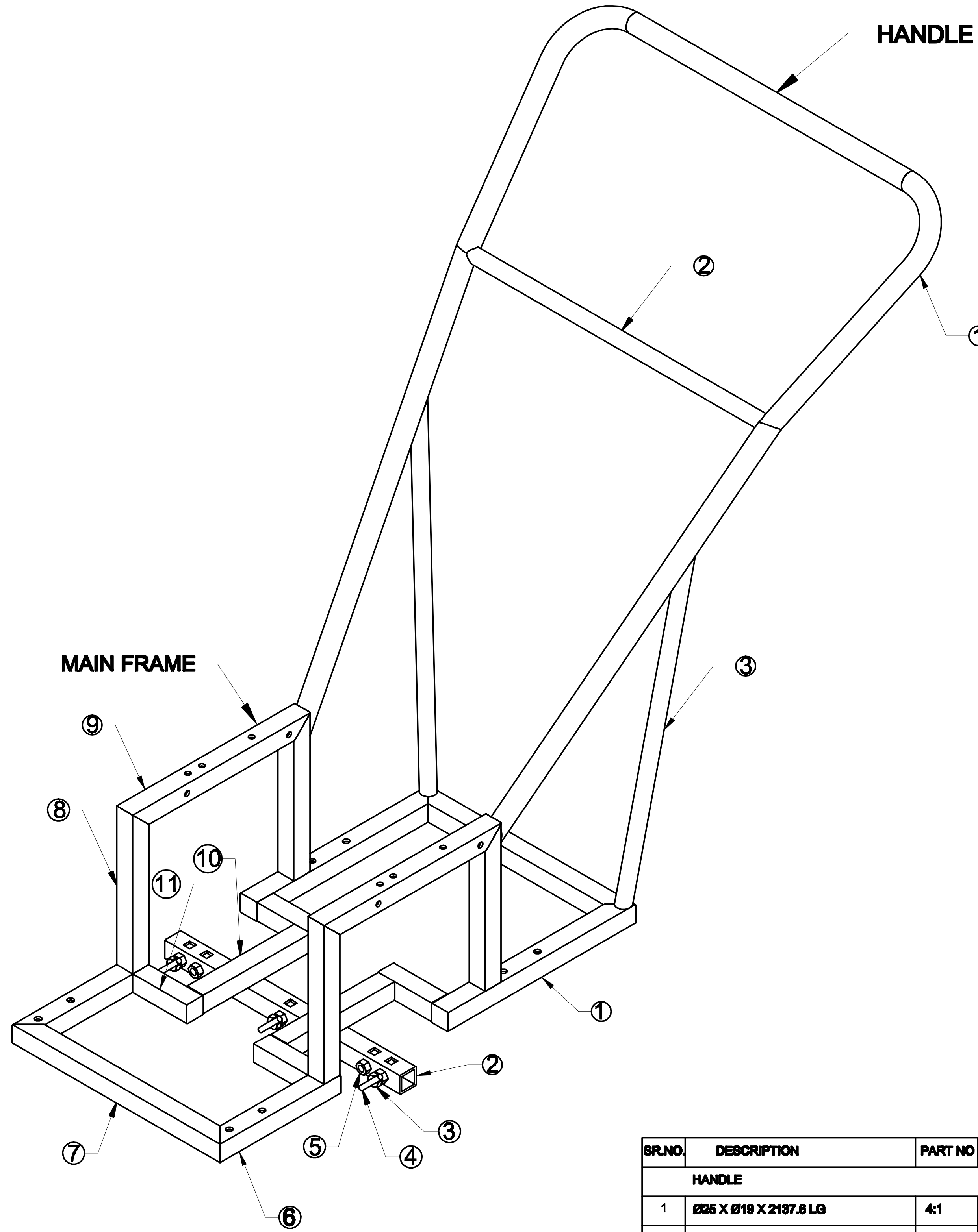


Fig. 3.4 ISOMETRIC VIEW OF MAIN FRAME

SR.NO.	DESCRIPTION	PART NO	QTY	MATL	
	HANDLE				
1	Ø25 X Ø19 X 2137.6 LG	4:1	01	MS	
2	Ø19 X Ø15 X 436 LG	4:2	01	MS	
3	Ø19 X Ø15 X 468 LG	4:3	02	MS	
	MAIN FRAME				
1	25 X 25 X 2.5 THKsq.pipe 280 LG	4:1	02	MS	
2	25 X 25 X 2.5 THKsq.pipe 350 LG	4:2	01	MS	
3	5/16" X 0.7 " LG HEX Nut Bolt	4:3	03	MS	
4	Ø6 X 40 LG	4:4	03	MS	
5	5/16" HEX Nut	4:5	03	MS	
6	25 X 25 X 2.5 THKsq.pipe 180 LG	4:6	02	MS	
7	25 X 25 X 2.5 THKsq.pipe 310 LG	4:7	02	MS	
8	25 X 25 X 2.5 THKsq.pipe 205 LG	4:8	04	MS	
9	25 X 25 X 2.5 THKsq.pipe 265 LG	4:9	02	MS	
10	25 X 25 X 2.5 THKsq.pipe 160 LG	4:10	02	MS	
11	25 X 25 X 2.5 THKsq.pipe 80 LG	4:11	04	MS	

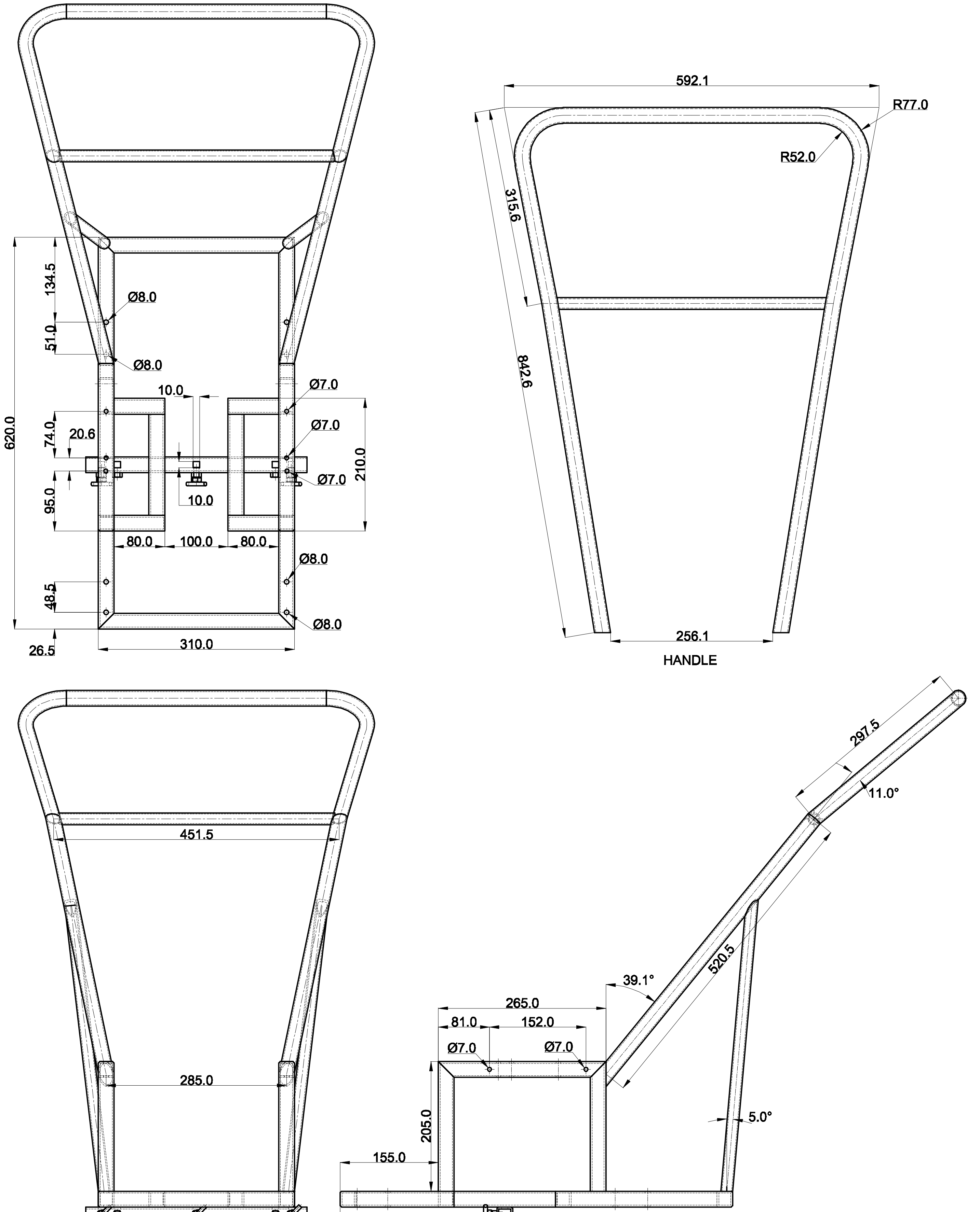


Fig. 3.5 ORTHOGRAPHIC VIEW OF MAIN FRAME ASSEMBLY

NOTES			
1. All DIMENSIONS ARE IN MM.			
2. ALL JOINTS ARE FULL WELDED	SCALE	SYMBOL	
3. REMOVE ALL SHARP CORNER	NTS		

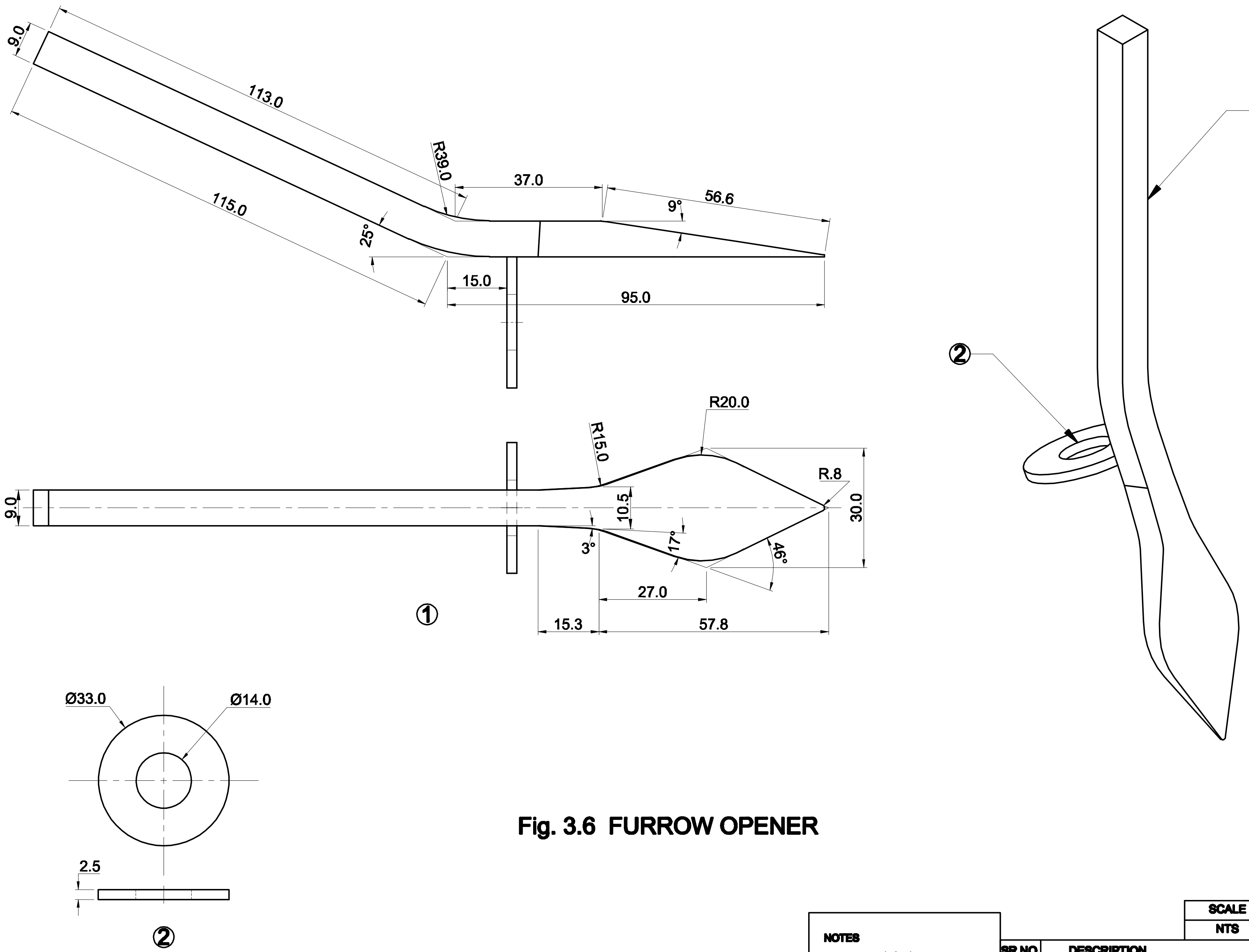


Fig. 3.6 FURROW OPENER

NOTES
1. All DIMENSIONS ARE IN MM.
2. ALL JOINTS ARE FULL WELDED
3. REMOVE ALL SHARP CORNER

SCALE	SYMBOL
NTS	

SR.NO.	DESCRIPTION	PART NO	QTY	MATL
1	9 X 9 X 210 LG Sq. solid bar	6:1	03	MS
2	Ø33 X Ø14 X 2.5 Thk.	6:2	03	MS

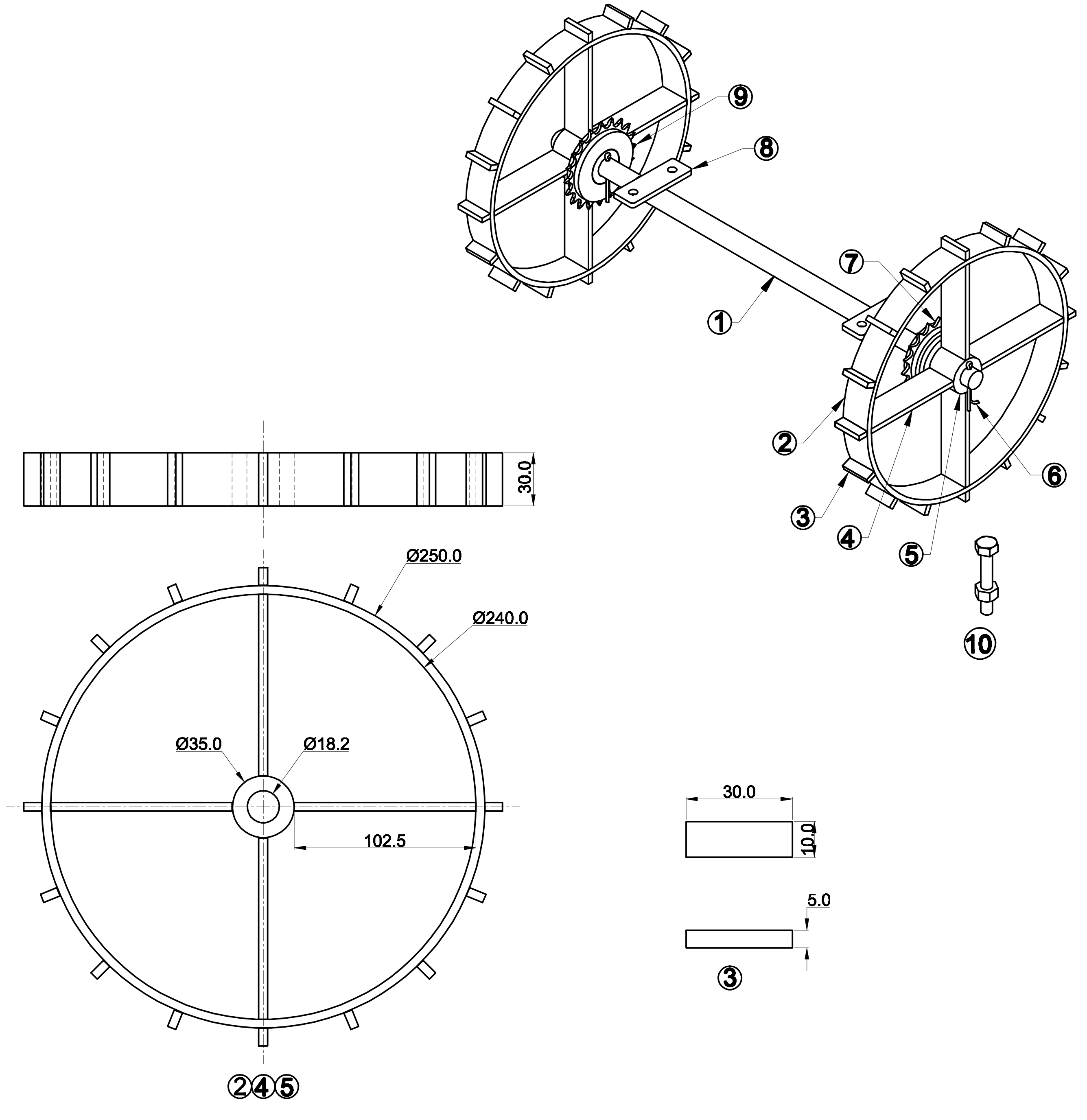


Fig. 3.7 GROUND WHEEL

SCALE	SYMBOL
NTS	

NOTES

1. All DIMENSIONS ARE IN MM.
2. ALL JOINTS ARE FULL WELDED
3. REMOVE ALL SHARP CORNER

SR.NO.	DESCRIPTION	PART NO	QTY	MATL	
1	Ø19 X Ø16 X 520 LG Shaft	7:1	01	MS	
2	30 X 5 THK Flat 770 LG	7:2	02	MS	
3	30 X 5 THK Flat 10 LG	7:3	032	MS	
4	30 X 5 THK Flat 102.5 LG	7:4	08	MS	
5	Ø35 X Ø18.2 X 30 LG	7:5	02	MS	
6	Ø3.2 Split pin X 55 LG	7:6	02	MS	
7	No. of teeth 18 Details Sheet No.- 14	7:7	02	MS	
8	75 X 25 X 5Thk.	7:8	02	MS	
9	No. of teeth 20 Details Sheet No.- 14	7:9	01	MS	
10	5/16" X 2" LG HEX Nut Bolt	7:10	04	MS	

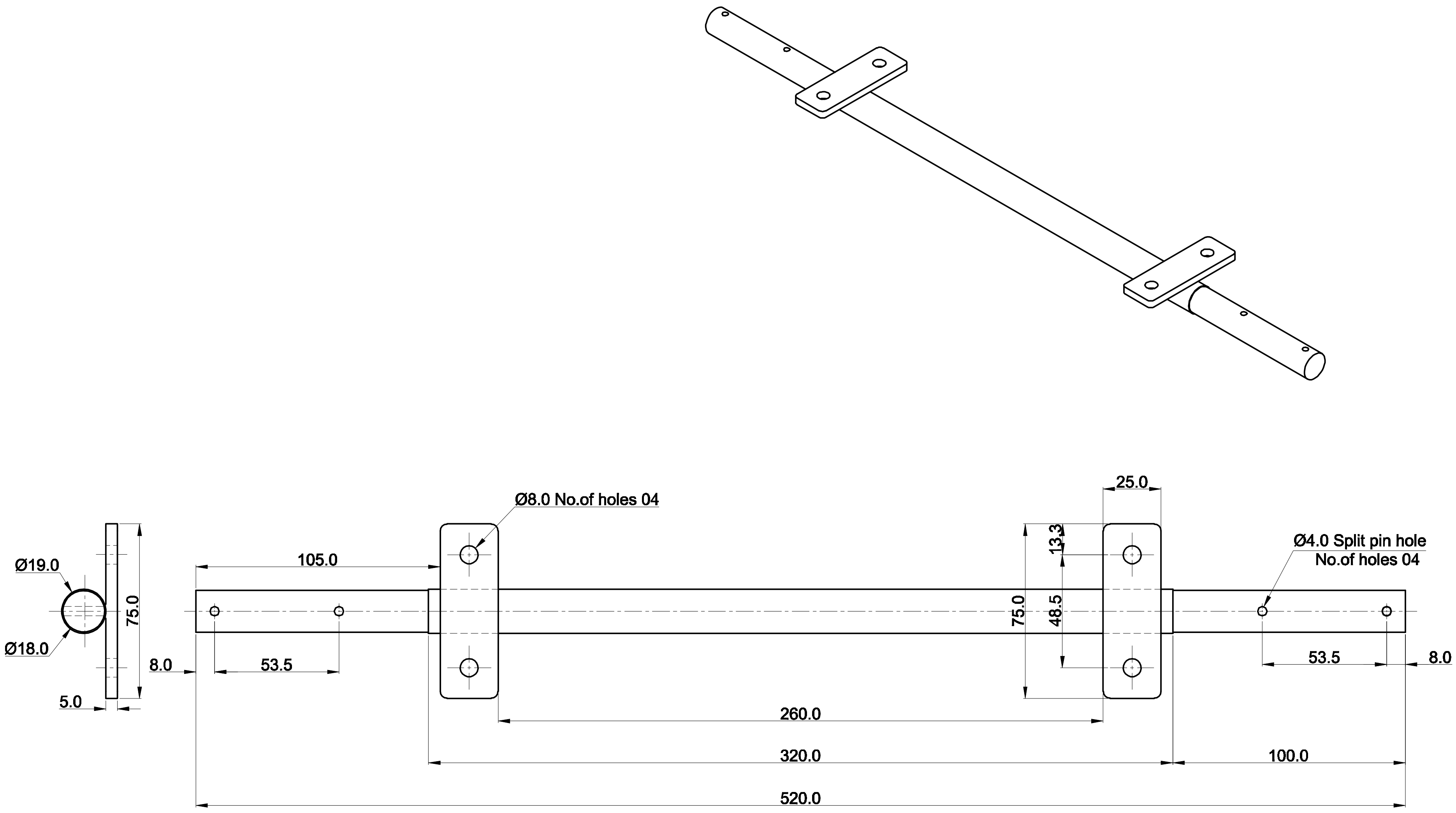
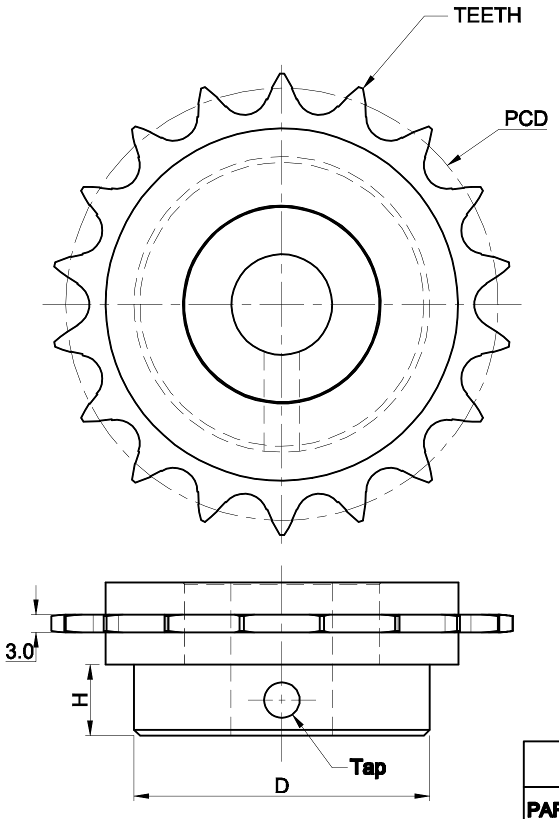


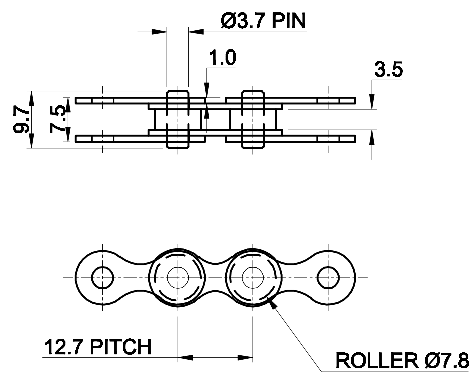
Fig. 3.8 GROUND WHEEL SHAFT

NOTES	SCALE	SYMBOL
1. All DIMENSIONS ARE IN MM. 2. ALL JOINTS ARE FULL WELDED 3. REMOVE ALL SHARP CORNER	NTS	



SPROCKET

SPROCKET DETAILS						
PAR.NO.	NO.OF TEETH	P.C.D	D	H	Tap	QTY.
A	16	65.1	Ø50.0	12	7/32"	01
B	20	81.0	Ø50.0	5	-	01
C	18	73.89	Ø50.0	12	7/32"	01
		73.89	Ø50.0	5	-	01



CHAIN

Fig. 3.9 CHAIN & SPROCKETS

SYMBOL	SYMBOL
NTS	

SR.NO.	DESCRIPTION	PART NO	QTY	MATL	
1	SPROCKET				
	A		01		
	B	9:1	01	STD.	
	C		02		
2	Chain	9:2	01	STD	

NOTES

1. All DIMENSIONS ARE IN MM.
2. REMOVE ALL SHARP CORNER

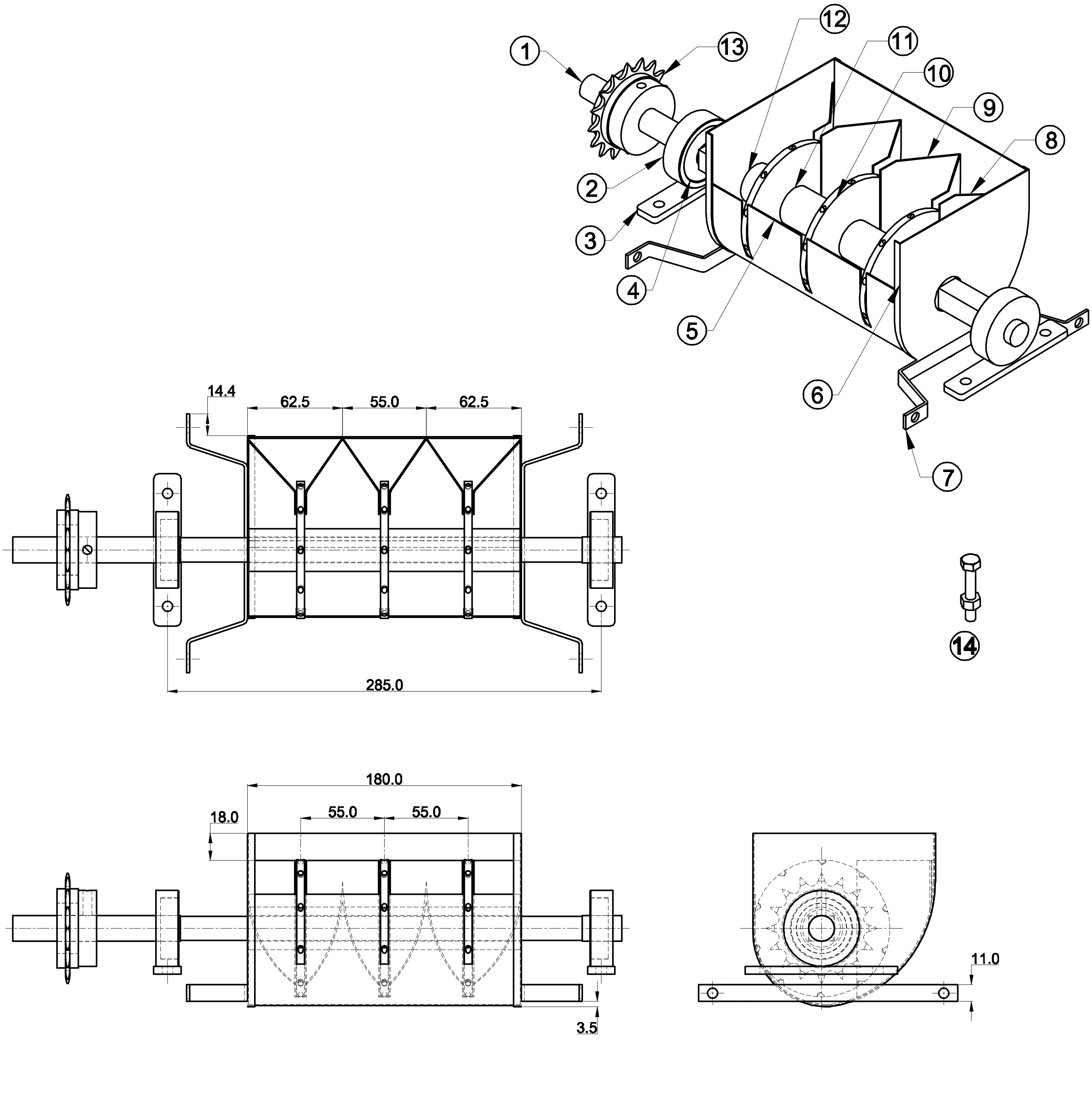


Fig. 3.10 SEED METERING UNIT

SCALE	SYMBOL
NTS	

SR.NO.	DESCRIPTION	PART NO	QTY	MATL	
1	Ø16.9 X sq.Bar 16X16X400 LG Shaft	10:1	01	MS	
2	Ø50 X Ø40.2 X 15 LG	10:2	02	MS	
3	100 X 18 X 5Thk.	10:3	02	MS	
4	Bearing No. 6203	10:4	02	MS	
5	249 X 178.4 X 21 Gauge MS Sheet	10:5	01	MS	
6	120 X 114 X 5, 21Gauge MS Sheet	10:6	02	MS	
7	11 X 2 Thk. Flat 223.5 LG.	10:7	02	MS	
8	89.7 X 60.6 , 21Gauge MS Sheet	10:8	02	MS	
9	89.7 X 114.2 , 21Gauge MS Sheet	10:9	02	MS	
10	Ø 90 X 5 Thk.	10:10	03	MS	
11	Ø 28 X 50 LG.	10:11	02	NL. PLST.	
12	Ø 28 X 31.6 LG.	10:12	02	NL. PLST.	
13	No. of teeth 16 Details Sheet No.- 14	10:13	01	MS	
14	1/4" X 1.5" LG HEX Nut Bolt	10:14	06	MS	

NOTES

1. All DIMENSIONS ARE IN MM.
2. ALL JOINTS ARE FULL WELDED
3. REMOVE ALL SHARP CORNER

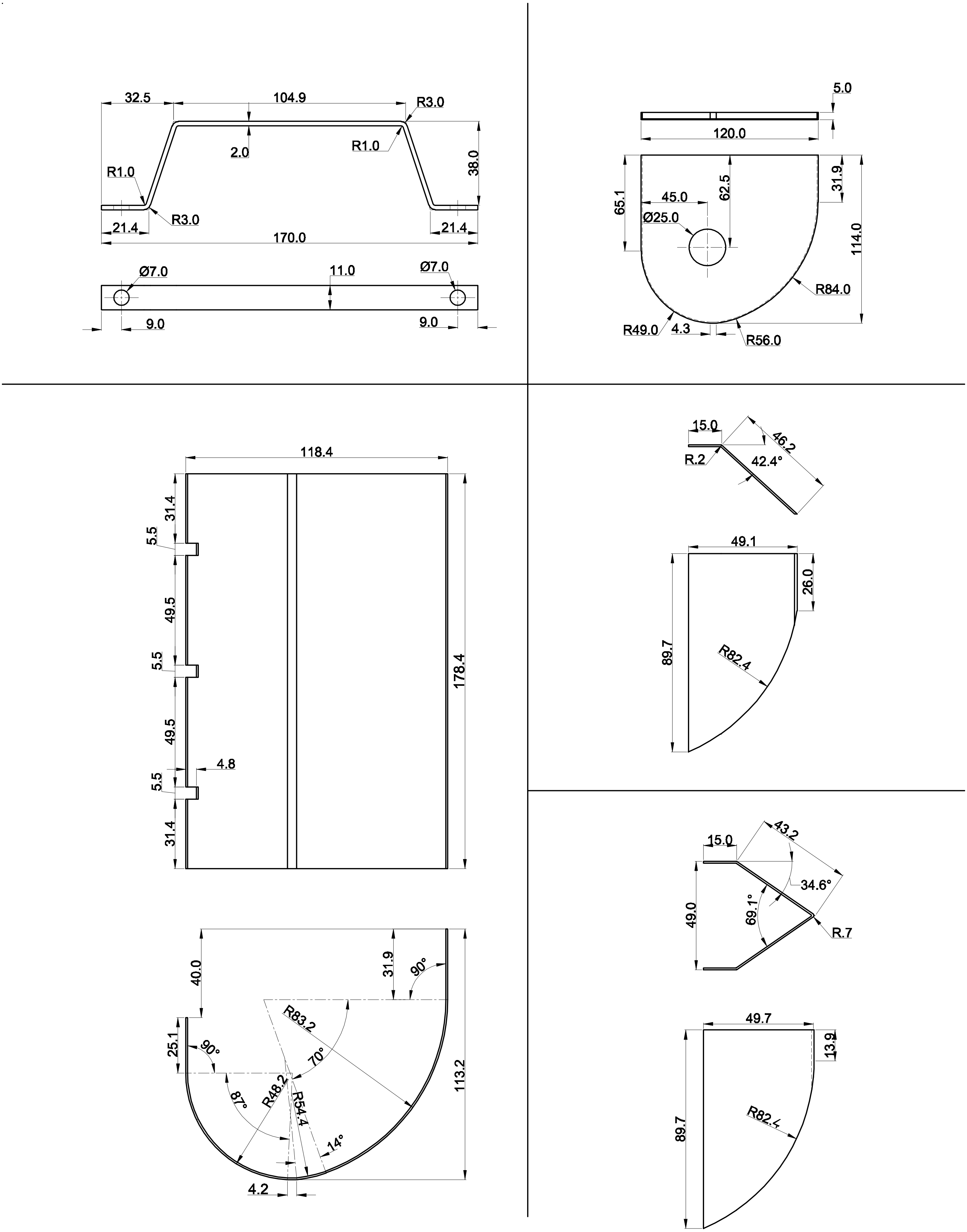


Fig. 3.11 SEED BOX

NOTES
1. All DIMENSIONS ARE IN MM.
2. ALL JOINTS ARE FULL WELDED
3. REMOVE ALL SHARP CORNER

SCALE	SYMBOL
NTS	

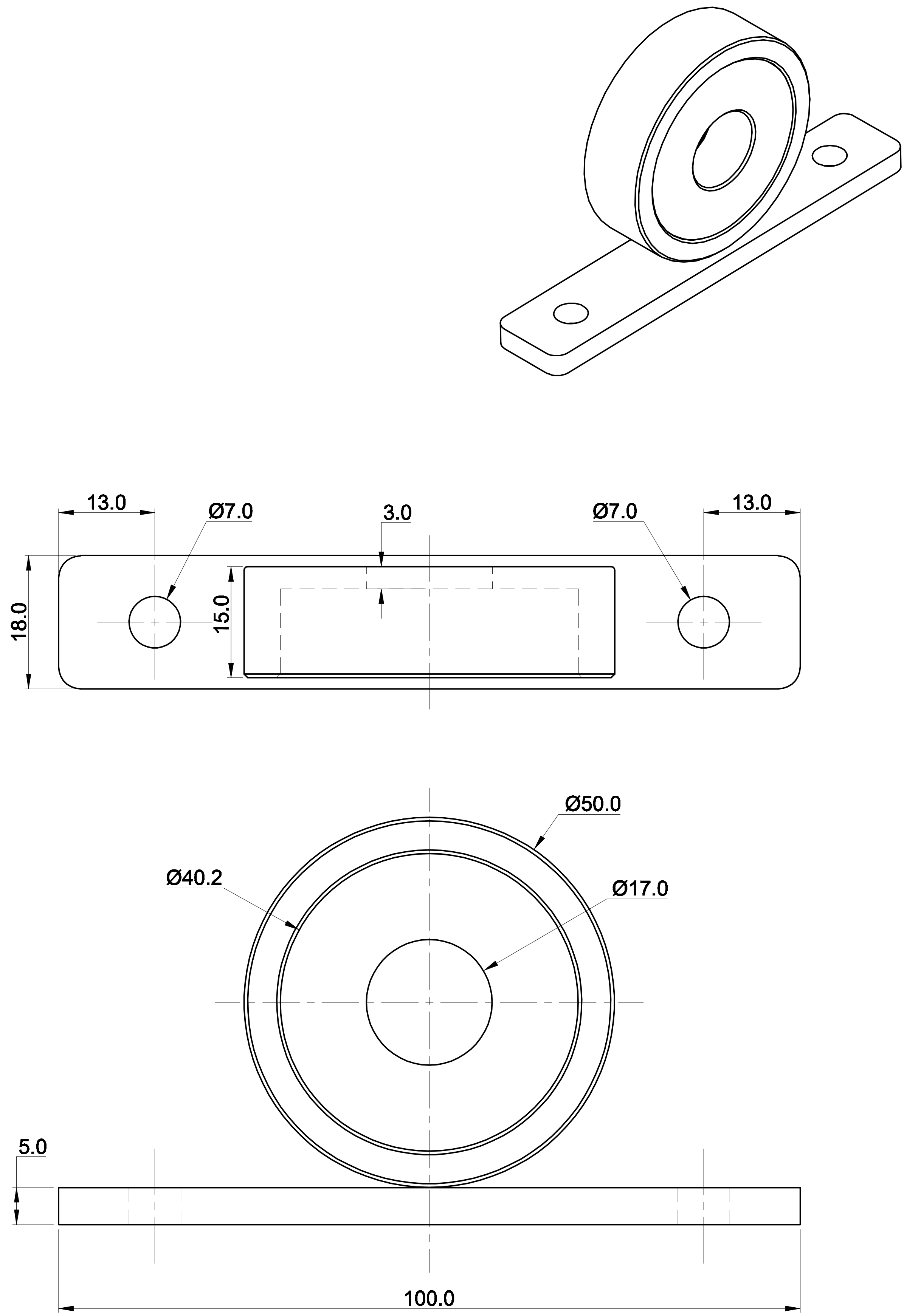
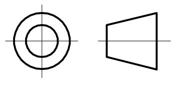
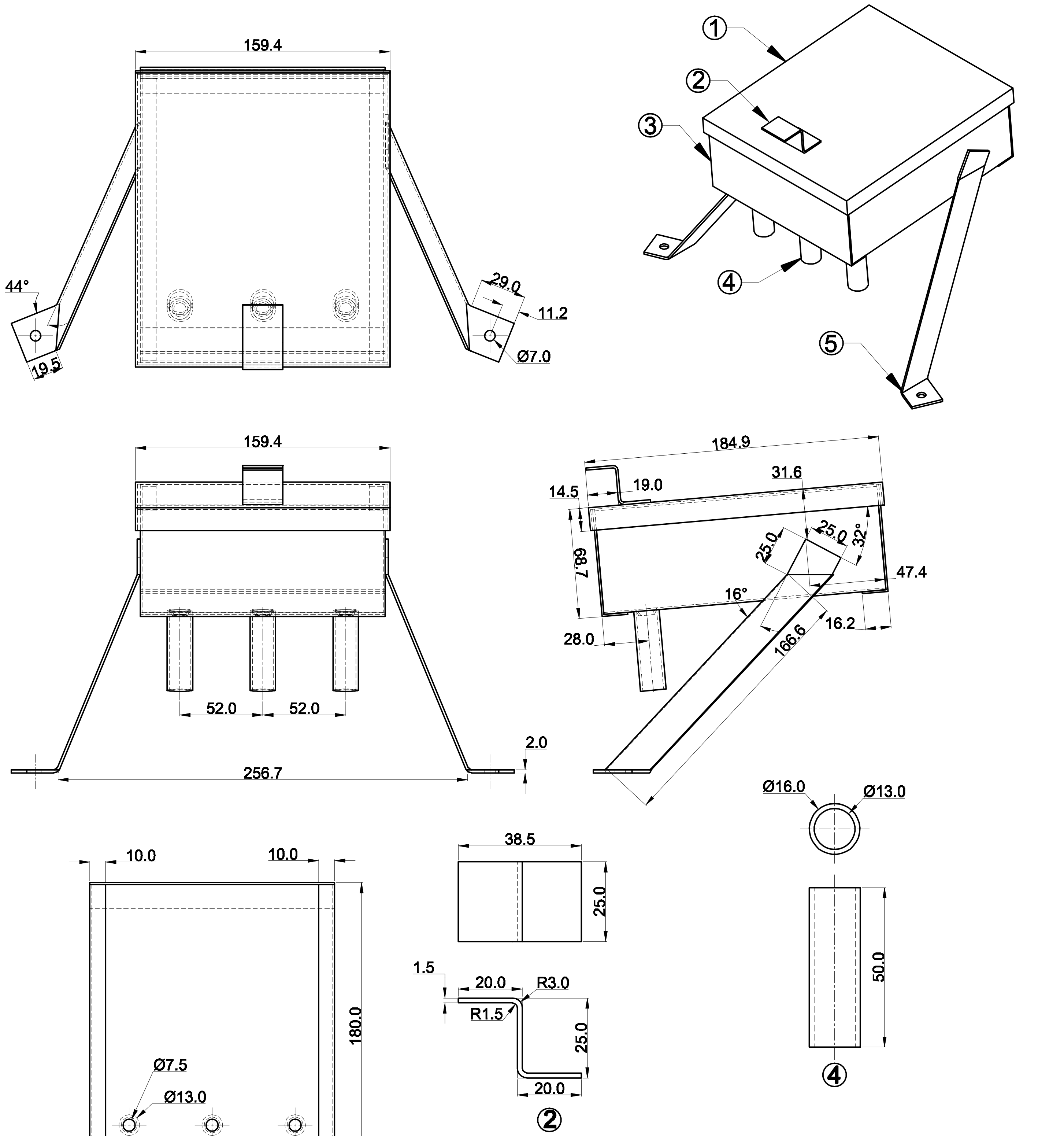


Fig. 3.12 BEARING BLOCK

NOTES			
1. All DIMENSIONS ARE IN MM. 2. ALL JOINTS ARE FULL WELDED 3. REMOVE ALL SHARP CORNER	SCALE NTS	SYMBOL	



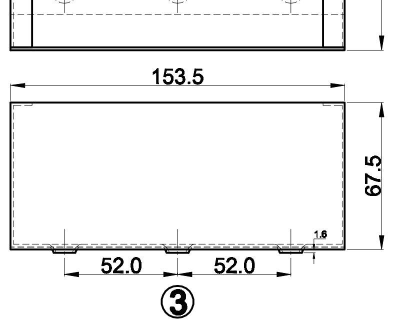


Fig. 3.13 AUXILIARY SEED BOX

SCALE	SYMBOL
NTS	

SR.NO.	DESCRIPTION	PART NO	QTY	MATL
1	159.4 X 184.9 X 14.5 ht. 16 Gauge MS Sheet	13:1	01	MS
2	25 X 1.5 THK Flat 60 LG	13:2	01	MS
3	153.5 X 180 X 67.5 ht. 16 Gauge MS Sheet	13:3	01	MS
4	Ø16 X Ø13 X 50 LG	13:4	03	MS
5	25 X 2 THK Flat 230 LG	13:5	02	MS

NOTES

1. All DIMENSIONS ARE IN MM.
2. ALL JOINTS ARE FULL WELDED
3. REMOVE ALL SHARP CORNER

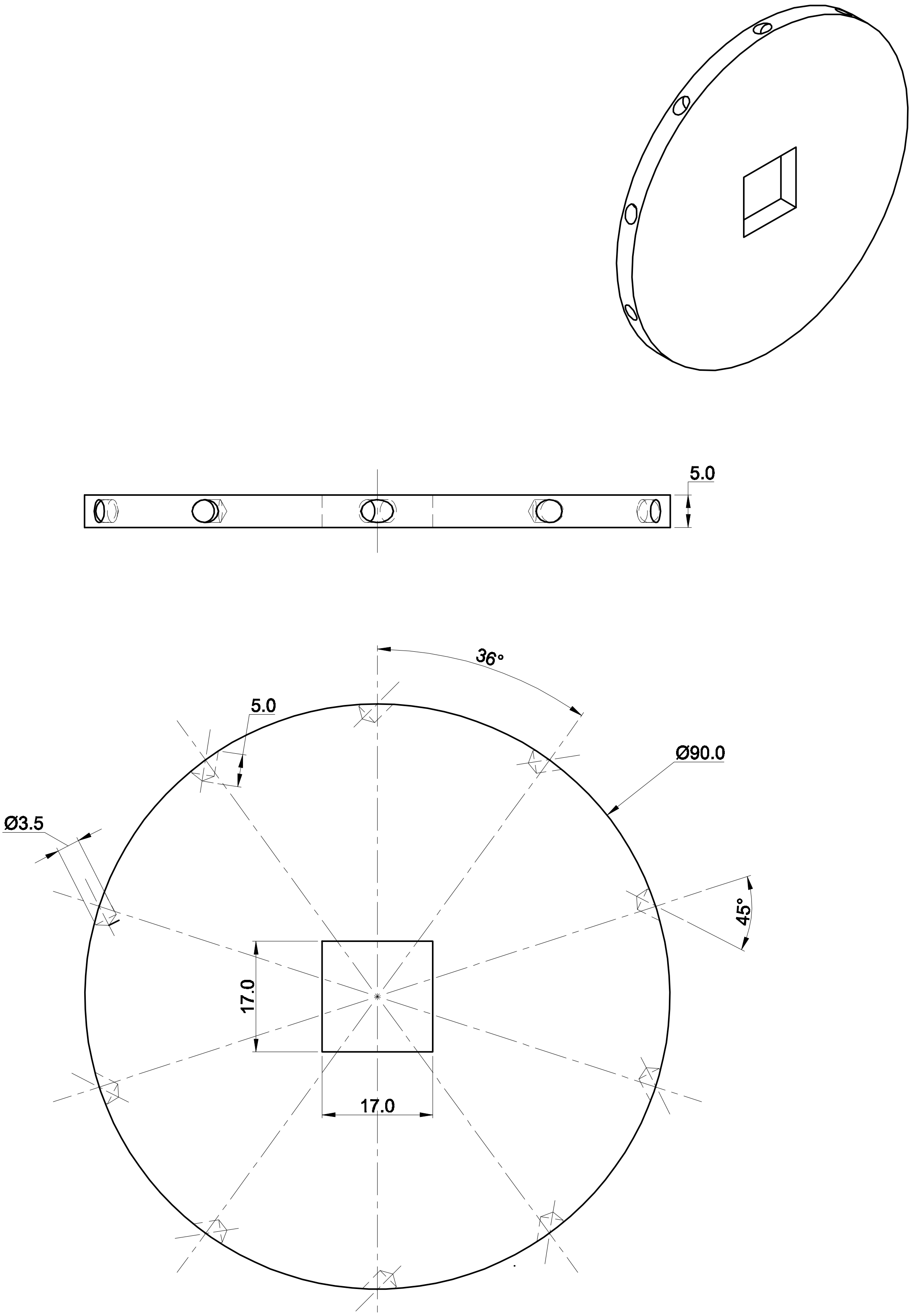
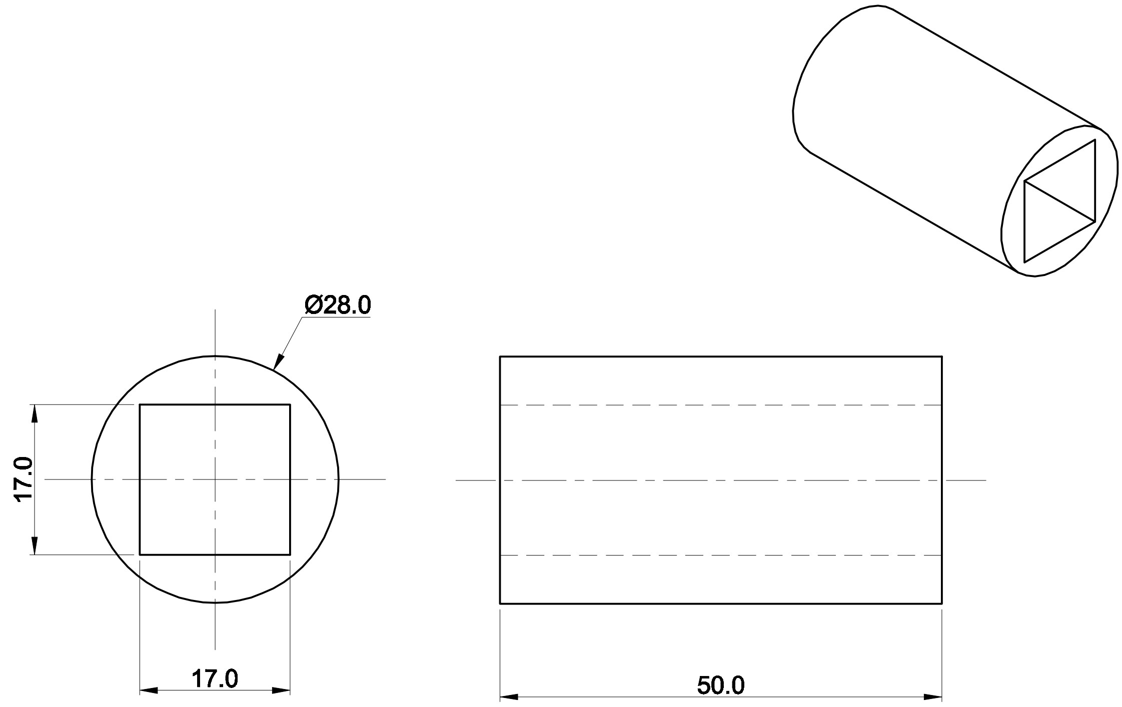


Fig. 3.14 SEED ROTOR

NOTES	SCALE	SYMBOL
1. All DIMENSIONS ARE IN MM.		
2. REMOVE ALL SHARP CORNER	NTS	



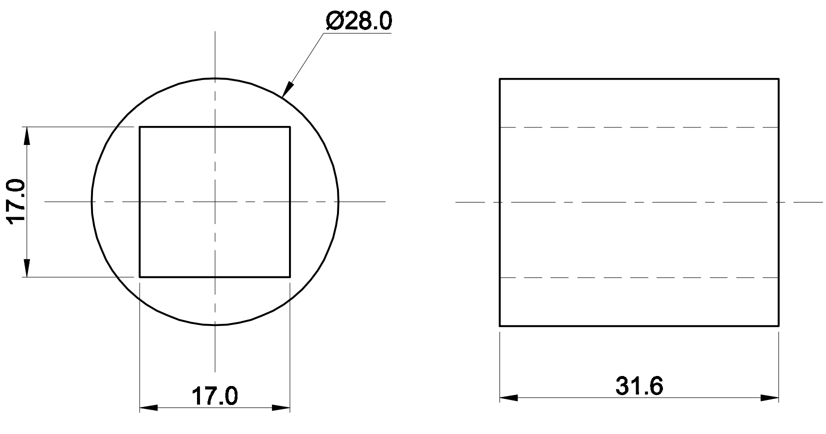


Fig. 3.15 SPACERS

NOTES	SCALE	SYMBOL
1. All DIMENSIONS ARE IN MM.		
2. ALL JOINTS ARE FULL WELDED		
3. REMOVE ALL SHARP CORNER	NTS	

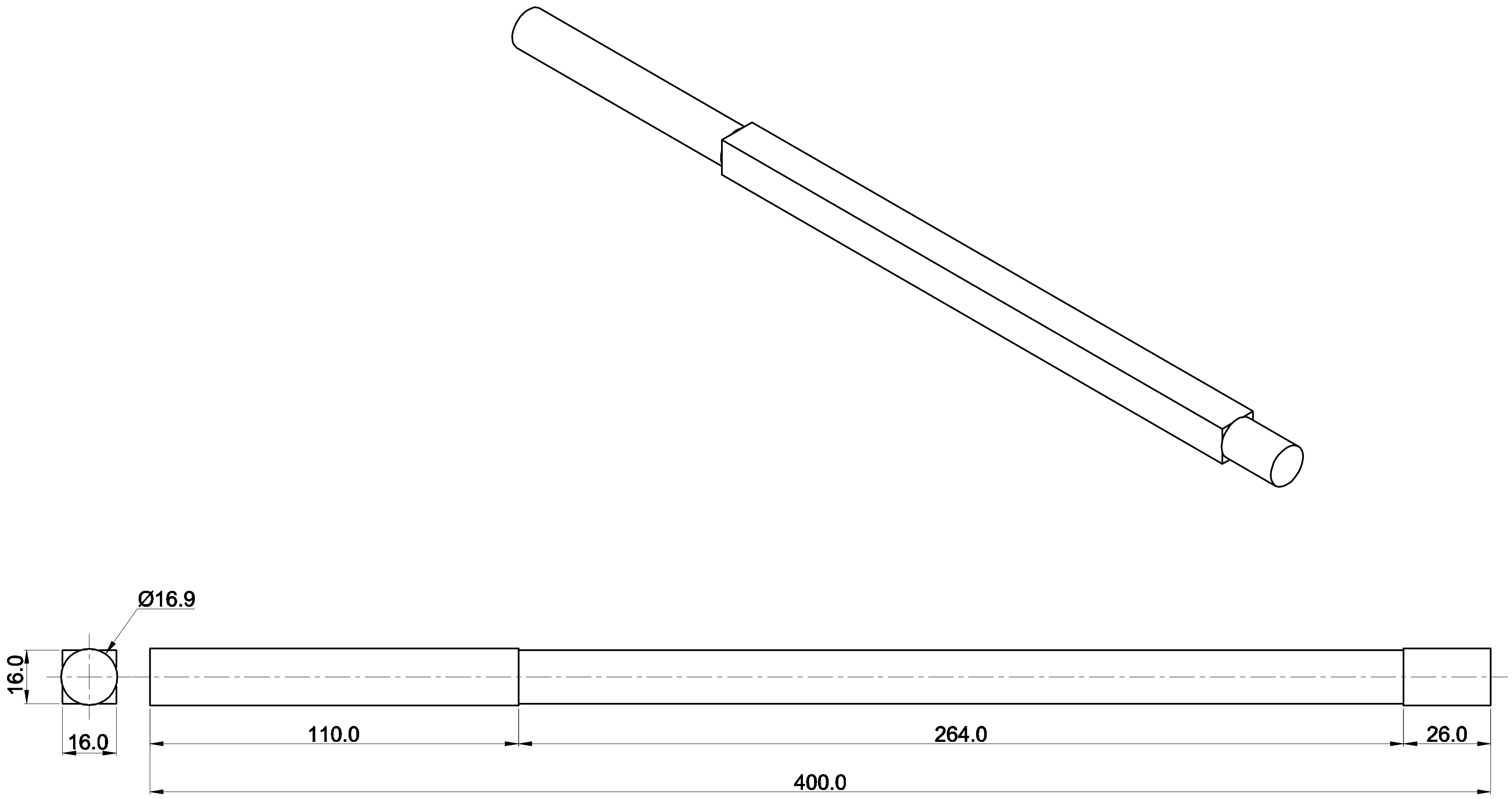


Fig. 3.16 ROTOR SHAFT

NOTES	SCALE	SYMBOL
1. All DIMENSIONS ARE IN MM. 2. ALL JOINTS ARE FULL WELDED 3. REMOVE ALL SHARP CORNER	NTS	

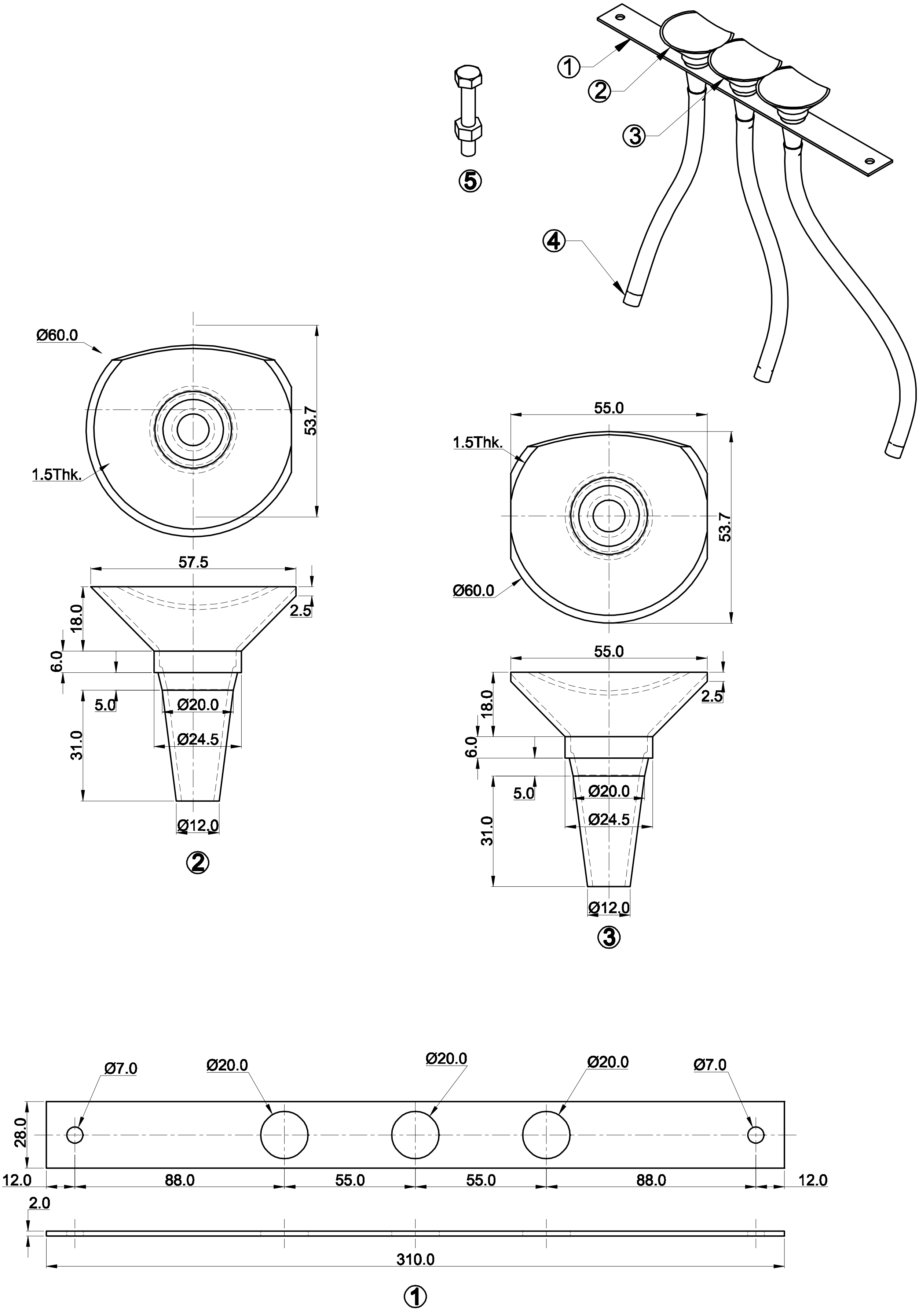
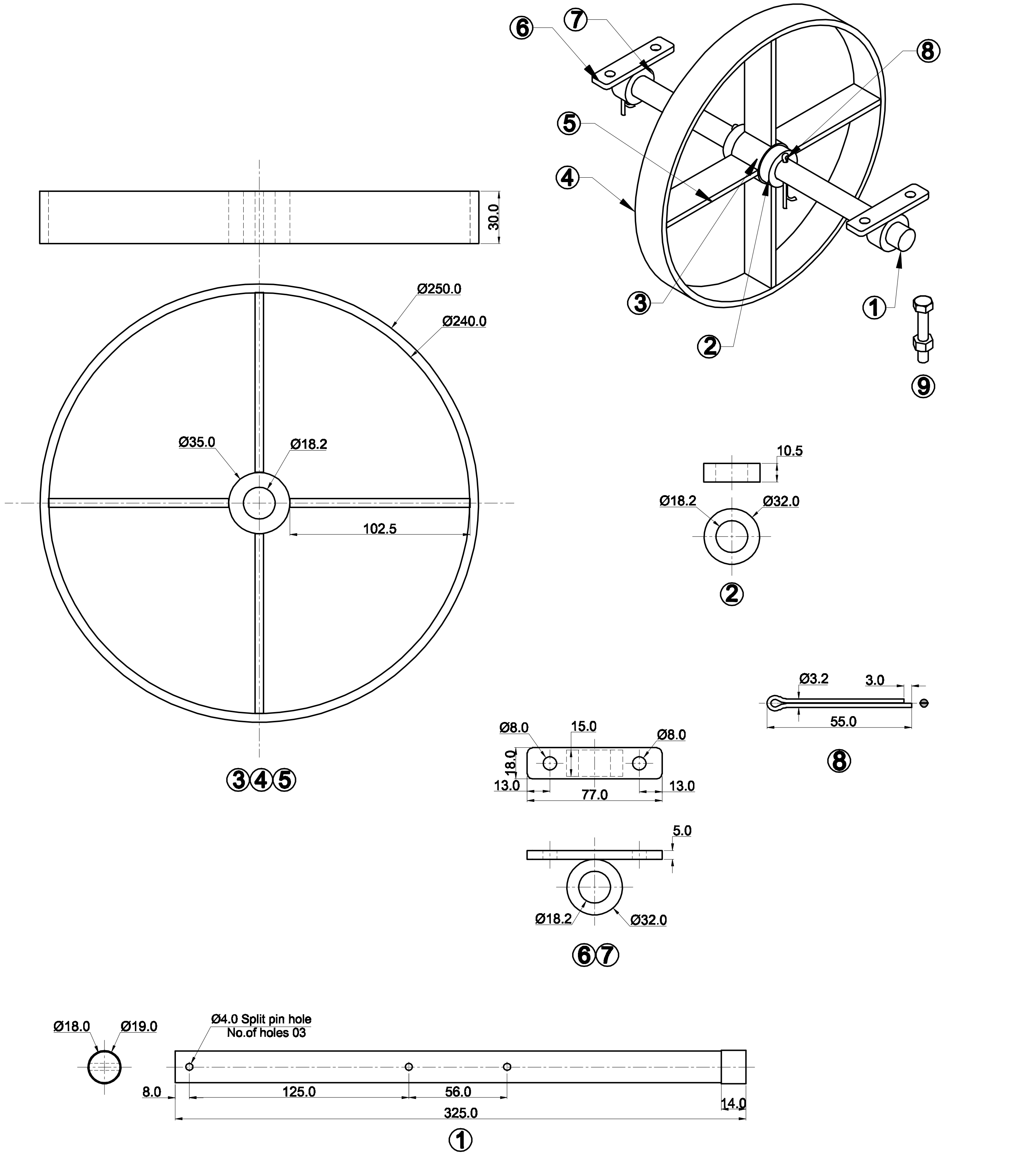


Fig. 3.17 SEED COLLECTING UNIT

SCALE	SYMBOL
NTS	

SR.NO.	DESCRIPTION	PART NO	QTY	MATL
1	28 X 2 THK Flat 310 LG	17:1	01	MS
2	FUNNEL	17:2	02	MS
3	FUNNEL	17:3	01	MS
4	Ø13 X Ø11 X 330 LG Tube	17:4	03	PVC
5	1/4" X 1.5" LG HEX Nut Bolt	17:5	02	MS

NOTES
1. All DIMENSIONS ARE IN MM.
2. ALL JOINTS ARE FULL WELDED
3. REMOVE ALL SHARP CORNER



SCALE	SYMBOL
NTS	

Fig. 3.18 SUPPOPRTING WHEEL

NOTES

1. All DIMENSIONS ARE IN MM.
2. ALL JOINTS ARE FULL WELDED
3. REMOVE ALL SHARP CORNER

SR.NO.	DESCRIPTION	PART NO	QTY	MATL	
1	Ø19 X Ø18 X 325 LG Shaft	18:1	01	MS	
2	Ø32 X Ø18.2 X 10.5 LG	18:2	02	MS	
3	Ø35 X Ø18.2 X 30 LG	18:3	01	MS	
4	30 X 5 THK Flat 770 LG	18:4	01	MS	
5	30 X 5 THK Flat 102.5 LG	18:5	04	MS	
6	77 X 18 X 5 Thk.	18:6	02	MS	
7	Ø32 X Ø18.2 X 15 LG	18:7	02	MS	
8	Ø3.2 Split pin X 55 LG	18:8	03	MS	
9	5/16" X 2" LG HEX Nut Bolt	18:9	04	MS	

Plate 3.1 Main frame

Plate 3.2 (a)

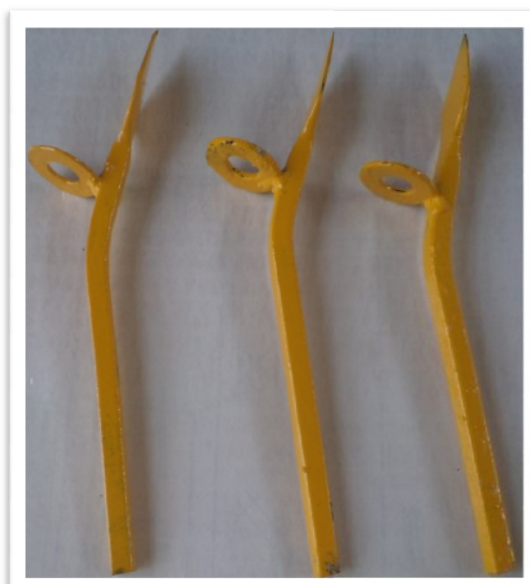


Plate 3.2 (b)

Plate 3.2 Furrow openers

Plate 3.3 Chain and sprocket arrangement for power transmission from ground wheel to rotor shaft

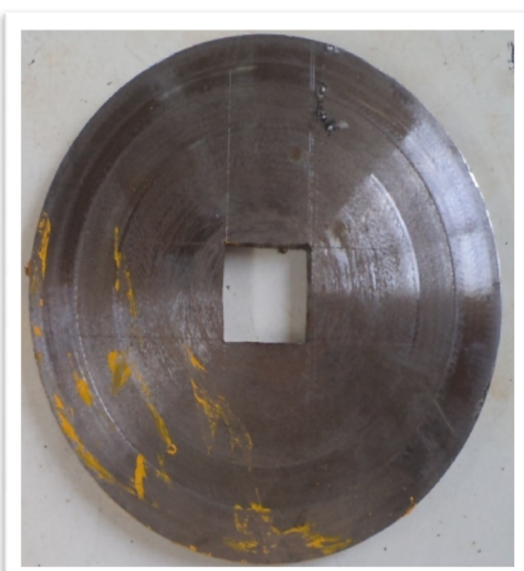


Plate 3.4 (a) **Plate 3.4 (b)**

Plate 3.4 Seed rotor

Plate 3.5 Seed box

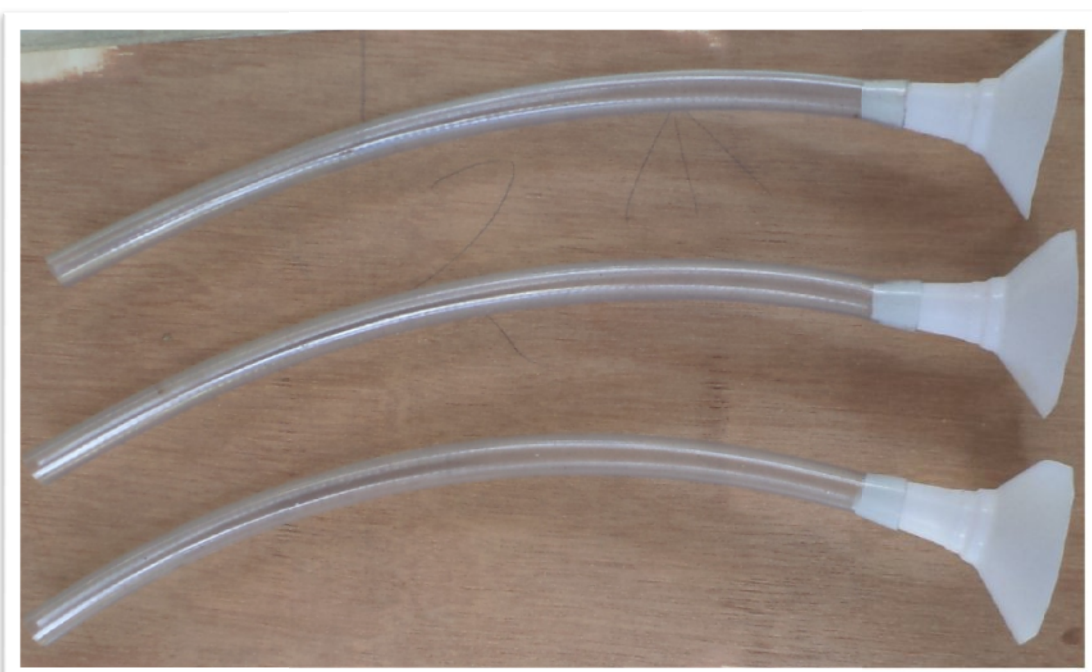


Plate 3.6 Collecting hoppers attached with seed tubes

Plate 3.7 Ground wheel **Plate 3.8 Supporting wheel**

Plate 3.9 Manually operated onion seed planter

Plate 4.1 Calibration of manually operated onion seed planter

Plate 4.2 Measurement of crop geometry

Plate 4.3 Measurement of plant population per hectare

Plate 4.4 Manually operated onion seed planter in operation