DEVELOPMENT OF MANUAL OPERATED DOUBLE ROW VEGETABLE SEED PLANTER

M. Tech. (Agril. Engg.) Thesis

by

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CERTIFICATE –I

This is to certify that the thesis entitled **"Development of Manual Operated Double Row Vegetable Seed Planter"** submitted in partial fulfilment of the requirements for the degree of "**Master of Technology** in **Agricultural Engineering**" of Indira Gandhi Krishi Vishwavidhyalay, Raipur, is a record of the bonafide research work carried out by **Chetna Verma** under my/our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or certificated course. All the assistance and help received during the course of the investigations have been duly acknowledged.

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Date: 23/02/2021

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This is to certify that the thesis entitled "**Development of Manual Operated Double Row Vegetable Seed Planter**" submitted by **Chetna Verma** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment of the requirements for the degree of **Master of Technology in Agricultural Engineering** in the Department of **Farm Machinery and Power Engineering** has been approved by the external evaluator and Student's Advisory Committee after oral examination, under the chairmanship of Head of the Department/Dean (in case of outcampii)

Signature of ~~Head~~ of the Department/

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Chetna Verma

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LIST OF SYMBOLS

Symbol	Description
mm	Milimeter
cm	Centimeter
m^2	meter square
%	Percentage
i.e.	that is
h	Hour
ha	Hectare
Kg	Kilogram
^{0}	Degree
kg/ha	Kilogram/hectare
G	Gram
h/ha	Hour/Hectare
Kmph	Kilometer per hour
KN	kilo newton
man-h/ha	man-hour/hectare
Rs.	Rupees
Viz.	Namely
T	Maximum shear stress
≈	Approximately equal to
hp	horse power
MT	Metric tonne
T. MT	Thousand metric tonne

LIST OF ABBREVIATIONS

SVCAET&RS	Swami Vivekananda College of Agricultural Engineering and Technology & Research Station
M. Tech.	Master of Technology
ICAR	Indian Council of Agricultural Research
IGKV	Indira Gandhi Krishi Vishwavidhyalaya
TFC	Theoretical Field Capacity
AFC	Actual Field Capacity
CV	Coefficient of Variance
MI	Miss Index
DI	Multiple Index
Engg.	Engineering
et al.	et alibi
etc.	Etcetera

THESIS ABSTRACT

Title of the thesis	:	Development of Manual Operated Double Row Vegetable Seed Planter
Full name of the student	:	Chetna Verma
Major subject	:	Farm Machinery and Power Engineering
Name and Address of the major advisor	:	Dr. S. V. Jogdand Professor, FMPE, SVCAET& RS Faculty of Agricultural engineering, IGKV, Raipur (CG)
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Signature of major advisor :

Signature of the student

Date 23/02/2021

Signature of head of the department

THESIS ABSTRACT

This study was undertaken to develop a planter to facilitate sowing of vegetable crop. Four crops were selected for the study namely okra, cowpea, dolichos bean and pea. For small and marginal farmers with a very small area < 1 hectare, the established machine is mainly useful. Sowing is a seed-planting method. The sowing objective is to position the seed at the desired depth and required row to row and plant to plant distance. A survey report shows that the home stead garden (0.2 ha.) locally known as 'Badi' covers 5% area of total area of

Chhattisgarh. Vegetable sowing is mainly carried out by broadcasting and line sowing methods, in Chhattisgarh.

The vegetable seed planter that has been developed is manually operated. It consists of a chain and sprocket transmission mechanism, seed hopper, main frame, drive wheel, support wheel, two numbers of furrow opener, metering mechanism for seed, plastic tubes for seed delivery, etc. The planter was made light in weight and also ergonomically appropriate for male and female workers pulling the planter. The developed planter is weighed to be 40 kg and Rs.17150 was its unit price. It had two furrow openers of T type mounted with depth adjustment on the frame. The seed metering mechanism consists of a seed rotor and a seed rotor cover box. As required for various crops, the seed rotor can have different grooves. The drive wheel with pegs was used for better grip and to avoid slippage. For laboratory and field tests both, the developed planter was evaluated. Calibration of seed and seed damage determination tests is performed in laboratory tests. Soil moisture content, bulk density and seed depth, row to row spacing and plant to plant spacing, miss index and multiple Index, Coefficient of Variance, theoretical field capacity, effective field capacity, plant population and field efficiency were performed in field tests. The seeds of local varieties of cowpea, okra, pea and dolichos bean was taken for experiment.

Metering disc number 12 and scale exposure number 5 gave nearest values of seeding mass rate (R_{sm}) 15.40 kg/ha for cowpea crop which is under recommended range for cowpea, 15-20 kg/ha. Metering disc number 12 and scale exposure number 6 gave nearest values of seeding mass rate 14.97 kg/ha which is under recommended range for okra crop, 12-14 kg/ha. Metering disc number 12 and scale exposure number 6 gave nearest values of seeding mass rate 152.80 kg/ha for pea crop which is under recommended range for pea, 150 kg/ha. Metering disc number 12 and scale exposure number 5 gave nearest values of seeding mass rate 31.21 kg/ha for dolichos bean crop which is under recommended range, 30-40 kg/ha. Theoretical seeding rate for cowpea, okra and dolichos bean was found 83334 seed per hectare and for pea it was 166667 seed per hectare.

It was found that no seed damage occurred during calibration for cowpea, okra and pea but 0.29% seed damage found in dolichos bean. Measured from five random samples from various field sites, it has been found that soil has 5.16 per cent average moisture content in dry conditions. The bulk density was found to be 1.38 g/cm^3 of the test plot soil. The average placement depth of seeds was found to be 4.08 cm, 4.28 cm, 4.08 cm and 4.2 cm for cowpea, okra pea and dolichos bean respectively. The average plant to plant distance was observed for cowpea 40.4 cm, for okra 40.26 cm, 20.58 cm for pea and 40.54 cm for dolichos bean. The theoretical field capacity was found to be 0.072 ha/h for all four crops.

The developed vegetable seed planter showed 1.2 km/h actual operating speed on an average. It was found that actual field capacity for cowpea, okra, pea and dolichos bean were 0.051, 0.050, 0.052, 0.049 ha/h respectively. Field efficiency was found 70.8 % for cowpea, 69.4 % for okra, 72.2 % for pea and 68% for dolichos bean. The plant population was recorded as 37500 plants per hectare for cowpea, 42000 plants per hectare for okra, 40300 plants per hectare for dolichos bean and 250000 average plants per hectare for pea crop.

The manufacturing cost of vegetable seed planter was 17150 Rs. Miss and Multiple Index was calculated for each crop. Miss Index was found 3%, 4%, 2% and 3% for cowpea, okra, pea and dolichos bean respectively and multiple Index was found 2% for cowpea, 3% for okra, 2% for pea and 2% for dolichos bean. Coefficient of variance along the line segment of 40 m was calculated and found to be 0.18, 0.25, 0.17 and 0.20 for cowpea, okra, pea and dolichos bean respectively. The sowing cost of each crops were calculated and found that 1039.2 Rs/ha for cowpea, 1060 Rs/ha for okra, 1019.2 Rs/ha for pea and 1081.6 Rs/ha for bean. The designed planter was rigid, durable, and light in weight, according to design considerations. The output of the vegetable planter for all selected crops was satisfactory in the laboratory as well as in actual field conditions.

शोध सारांश

शोध शीर्षक	: हस्तचलित दोहरी पंक्ति सब्जी बुवाई यंत्र का विकास
छात्रा का नाम	: चेतना वर्मा
प्रमुख विषय	: कृषि यंत्र एवं शक्ति अभियांत्रिकी
मुख्य सलाहकार का नाम व पता	: डॉ. एस. व्ही. जोगदंड प्राध्यापक, कृषि यंत्र एवं शक्ति अभियांत्रिकी इं. गां. कृ. वि. रायपुर, (छ.ग.)
पूरा पता	: स्वामी विवेकानंद कृषि अभियांत्रिकी एवं प्रौद्योगिकी महाविद्यालय एवं अनुसंधान केन्द्र रायपुर इंदिरा गांधी कृषि विश्वविद्यालय रायपुर, छत्तीसगढ़
उपाधि से सम्मानित किया जाना है	: कृषि अभियांत्रिकी में स्नातकोत्तर (मास्टर ऑफ टेक्नोलॉजी)

Chetna
छात्रा के हस्ताक्षर

मुख्य सलाहकार के हस्ताक्षर

दिनांक 23/2/2024

विभागाध्यक्ष के हस्ताक्षर

सारांश

यह अध्ययन चयनित फसल के लिए सब्जियों की बीज बोने वाले यंत्र के विकास के लिए किया गया है। दोहरी पंक्ति वाले सब्जी बुवाई यंत्र का परीक्षण बरबट्टी, भिण्डी, सेम और मटर के लिए किया गया । बहुत छोटे क्षेत्र के साथ छोटे और सीमांत किसानों के लिए 1 हेक्टेयर से भी कम क्षेत्र के लिए स्थापित यंत्र मुख्य रूप से उपयोगी है । बुवाई एक बीज रोपण विधि है । बुवाई का उद्देश्य बीज को वांछित गहराई और आवश्यक पंक्ति से पंक्ति और पौधे से पौधे की दूरी पर स्थित है । एक सर्वेक्षण रिपोर्ट से पता चलता है कि स्थानीय रूप से 'बाड़ी' के रूप में जाना जाने वाला घरों में स्थित बगीचा (0.2 हेक्टेयर) छत्तीसगढ़ के कुल क्षेत्रफल का 5% क्षेत्र शामिल है । छत्तीसगढ़ के किसान सब्जियों की बुवाई

के लिए स्वदेशी विधियों का उपयोग कर रहे हैं, जैसे प्रसारण पंक्ति बुवाई, स्वदेशी हल आदि जिसके परिणामस्वरूप इसके असंतोष प्रदर्शन के कारण कम उत्पादकता होती है।

जिस बीज यंत्र को विकसीत किया गया है, वह हस्तचलित मानव द्वारा संचालित होता है। इसमें एक चेन ओर स्प्रोकेट पॉवर ट्रांसमिश सिस्टम सीड हॉपर, फ्रेम, ड्राइव व्हील, सपोर्ट व्हील दो नम्बर का फरो ओपनर, सीड मीटरिंग मैकेनिज्म, डिलीवरी ट्यूब इत्यादि शामिल है । इस यंत्र को वजन में हल्का बनाया गया है और यह महिला एवं पुरूष दोनों के लिए एर्गोनोमिक रूप से उपयुक्त है।

विकसित सब्जी बुवाई यंत्र का वजन 40 किग्रा है और इसकी युनिट की कीमत 17150 रूप्ये है। इसमें टी आकार का फ्रेम दो फरो ओपनर था जिसमें मुख्य फ्रेम पर आरोहित किया गया था । इस बीज बुवाई यंत्र में एक बीज रोटर और एक बीज रोटर कवर बॉक्स है । विभिन्न फसलों के लिए आवश्यकतानुसार, बीज रोटर में विभिन्न खांचे हो सकते है। ड्राइव वहील को बेहतर कर्षण के लिए और फिसलन से बचाने के लिए खूंटे के साथ पहिया के रूप में इस्तेमाल किया गया है। प्रयोगशाला और क्षेत्र में परीक्षण कर विकसित सब्जी बुवाई यंत्र का मुल्यांकन किया गया है । बीज क्षति निर्धारण परीक्षणों का अंशाकन प्रयोगशाला परीक्षणों में गहराई, पंक्ति रिक्ती के लिए पंक्ति और पौधों की रिक्ती दर, सैद्धांतिक क्षेत्र, वास्तविक क्षेत्र क्षमता, क्षेत्र दक्षता और पौधों की आबादी को क्षेत्र परीक्षणों में प्रदर्शित किया गया है। बरबटटी, भिण्डी, मटर ओर सेम की स्थानीय किस्मों के बीजों को प्रयोग के लिए लिया गया है।

बरबट्टी की फसल के लिए पैमाइश डिस्क नं 5 के 12 और स्केल एक्सपोजर ने बीजारोपण द्रव्यमान दर 15.40 किलोग्राम प्रति हेक्टेयर के निकटतम मान दिये जो कि 15–20 किलोग्राम प्रति हैक्टेयर की सीमा में हैं । भिण्डी की फसल के लिए पैमाइश डिस्क नं. 6 के 12 और स्केल एक्सपोजर ने बीज दर 14.97 किलोग्राम प्रति हेक्टेयर के निकटतम मान दिये जो कि 12–14 किलोग्राम प्रति हेक्टेयर की सीमा में है । मटर की फसल के लिए पैमाइश डिस्क नं.6 के 12 और स्केल एक्सपोजर ने बीज दर 152.80 किलोग्राम प्रति हेक्टेयर के निकटतम मान दिये जो कि 150 किलोग्राम प्रति हेक्टेयर की सीमा में है । सेम की फसल के लिए पैमाइश डिस्क नं. 5 के 12 ओर स्केल एक्सपोजर ने बीज दर 31.21 किलोग्राम प्रति हेक्टेयर के निकटतम मान दिये जो कि 30.40 किलोग्राम प्रति हेक्टेयर की सीमा में है । बरबट्टी, भिण्डी, सेम के लिए सैद्धांतिक बीज दर 83334 बीज प्रति हेक्टेयर और मटर के लिए 166667 बीज प्रति हेक्टेयर पाया गया । यह पाया गया कि बरबट्टी, भिण्डी और मटर के लिए परीक्षण के दौरान कोई बीज क्षति नही हुई, लेकिन सेम में 0.29 % बीज क्षति हुई। विभिन्न क्षेत्र की साइटों से पांच यादृच्छिक नमूनों से मापा गयाए शुष्क परिस्थितियों में मिट्टी की औसत नमी 5.16 प्रतिशत पाई गई । परीक्षण प्लॉट मिट्टी का थेक घनत्व 1.38 ग्राम प्रति सेन्टीमीटर 3 पाया गया ।

बीजों की बुवाइ की औसत गहराई बरबट्टी के लिए 4.08 सेमी भिण्डी के लिए 4.28 सेमी मटर के लिए 4.08 सेमी और सेम के लिए 4.2 सेमी देखी गई । बीज की दूरी के लिए औसत बीज बरबट्टी के लिए 40.4 सेमी, भिण्डी के लिए 40.26 सेमी, मटर के लिए 20.58 सेमी और सेम के लिए 40.54 सेमी पाया गया । सभी चार फसलों के लिए सैद्धांतिक क्षे. क्षमता 0.072 हेक्टेयर प्रति घंटा पाया गया। विकसित वनस्पति बीज बोने वाले यं. की संचालन की वास्तविक औसत यात्रा गति 1.2 किलोमीटर प्रति घंटा पाया

गया है। यह पाया गया कि बरबट्टी, भिण्डी, मटर और सेम के लिए वास्तविक क्षेत्र क्षमता क्रमशः 0.051, 0. 050, 0.052, 0.049 हेक्टेयर प्रति घंटा है।

बरबट्टी के लिए फील्ड दक्षता 70.8%, भिण्डी के लिए 69.4%, मटर के लिए 72.2% और सेम के लिए 68% पाया गया । प्रति हेक्टेयर औसत पौधे की आबादी बरबट्टी के लिए 37500, भिण्डी के लिए 42000, सेम के लिए 40300 और मटर के लिए 250000 दर्ज की गई है। विकसित वनस्पति बीज बुवाई यंत्र की लागत 17150 रूप्ये है । प्रत्येक फसल के लिए मिस और मल्टीपल इंडेक्स की गणना की गई। मिस इंडेक्स क्रमशः 3%, 4%, 2% और 3% बरबट्टी, भिण्डी, मटर और सेम के लिए पाया गया और कई इंडेक्स में 2% बरबट्टी के लिए, 3% भिण्डी के लिए, 2% मटर के लिए और 2% सेम के लिए पाया गया । 40 मीटर की लाइन सेगमेंट के साथ भिन्नता के गुणांक की गणना की गई और क्रमशः 0.18, 0.25, 0.17 और 0.20 को बरबट्टीए भिण्डी, मटर और सेम के लिए पाया गया । यह पाया गया कि बरबट्टी की बुवाई की लागत 1039.2 रूप्ये प्रति हेक्टेयर भिण्डी की बुवाई की लागत 1060 रूपये प्रति हेक्टेयरए मअर 1019.2 रूपये प्रति हेक्टेयर और सेम की बुवाई की लागत 1081.6 रूपये प्रति हेक्टेयर है। विकसित किये गये विचारों के अनुसार विकसित किया गया यंत्र कठोर, टिकाऊ, मजबूत और वजन में हल्का है। सभी चयनित फसलों के लिए वनस्पति पौधों का उत्पादन प्रयोगशाला के साथ–साथ वास्तविक क्षेत्रों की स्थितियों में संतोषजनक है।

CHAPTER I

INTRODUCTION

Indian food essentially contains vegetables in people's daily diet. Vegetable contains high nutritional value. Farmers prefer to grow vegetables for higher yield, short duration, economic return and ease of marketing near the growing location. India is a country where diverse agro- climates with distinct seasons are found. It provides a good opportunity to grow a wide array of vegetables. Vegetables and fruits account for almost 90% of the country's total horticulture output. Vegetables in our normal intake are important sources of protein, vitamins, minerals, dietary fibers, micronutrients, antioxidants and photochemical.

Vegetables have a specific important position of providing valuable biological ingredients to the peoples of India. An increase in production has been recorded in horticulture production over the past decade. In this period, 2.6 percent per annum growth in area as well as 4.8 percent growth in production was recorded. During 2017-18, the production of horticulture crops was 311.71 MT from an area of 25.43 million ha. The production of vegetable has increased from 101.2 MT to 184.40 MT since 2004-05 to 2017-18. (Source: - Horticulture statistics at a glance 2018)

In Chhattisgarh, production of vegetables was 6910.32 thousand MT from an area of 498.93 thousand ha. (Source: - Ministry of agriculture & farmers welfare, 2018-19).

The home stead garden (0.2ha.) locally known as 'Badi' covers 5% area of total area of Chhattisgarh. The soil of Badi are entisols and inceptisol, fenced, upland and sloppy. Most of the badi contains one shallow dug well. Most of the farmers having Badi in their backyard and they use to practice vegetable farming for their own consumption. Most of the farmers cultivate Badi by raising vegetables only. But not any suitable sowing machine has available for farmers. Previously single row manual operated vegetable planter has developed but the capacity of that machine is low. So the objectives of the research work will fulfil the need of the farmers with high capacity, more efficiency and low cost.

Due to the ideal agro-climatic situation, especially mellow winter in the development period of the product, which provides a decent potential for okra seed generation, the Chhattisgarh fields have an extension package for okra seed generation. In addition, Chhattisgarh's agro-climatic condition is also beneficial for crops such as cauliflower, cowpea, cabbage, brinjal, bottle gourd, frenchbean, pea, etc. and spices such as coriander, fenugreek, turmeric, ginger, chili pepper, garlic, methi, etc.

Chhattisgarh has also been referred to as Central India's Rice Bowl, with Paddy being the main crop. Cereals such as kodo-kutki, maize & millets, oilseeds such as soybean, groundnut, sunflower and Niger, and pulses such as kulthi and tur are also grown in addition to the paddy crop. The efficiency so far is not very good. This has given the horticulture area a fresh momentum, as the country is also suitable for growing fruits and various vegetables. There is a need to lay greater emphasis on improving Chhattisgarh's irrigation resources and on rigorously endorsing horticulture in Chhattisgarh.

In Chhattisgarh, all vegetable crops such as Cucurbits, Solaneian crops, Beans, Cauliflower, Cabbage etc. are also grown very well.

The technique of planting seeds is sowing. The primary guideline for the sowing task is to position the seed and manure at the appropriate depth in columns, cover the seeds with soil and provide valid compaction over the seed. Different approaches of seed sowing techniques are being used in India.

Following are the different types of seed sowing

- **Broadcasting**: - In this process, seed is dispersed into the prepared field by hand and then covered with a wooden plank. By this process, crops such as wheat, paddy, methi, etc. are sown. The advantage of this technique is that it is a fast and simple technique and does not require skilled labour. While its drawback is that more seed is required and the standing of plants is not uniform.

- **Dibbling**: - In this method seed is placed in (+) mark made in the field with the help of maker as per crop requirement. Dibbling is done by the implement called dibbler.
- **Drilling or line sowing**: - In this method seed is placed into soil with the help of implement such as seed drill, seed cum fertilizer drill and covered by plank or harrow.
- Precision planting is the system of accurate insertion of single seeds in rows at approximately equal intervals, and hill dropping is placing groups of seed in rows at approximately equal intervals.
- Another way to sow the seeds is by using a straight forward system consisting of a bamboo tube connected to a plough with a funnel on it.

It was found that there is a lot of problems occurred in seed sowing as follows:

a) High expense for purchasing the equipment.
b) Handling of equipment because of over abundance load of the apparatuses.
c) Dependency on bull driven machines.
d) Musculoskeletal clutters due to sowing by bowing and sowing.
e) Losses of seeds mainly in broadcasting.

The basic requirement for small-scale farming machines is that they should be suitable for small and marginal farmers, straightforward in terms of planning and creativity, and versatile for use in different farming operations. Farmers of Chhattisgarh use indigenous vegetable sowing methods, such as broadcasting, line sowing, etc.

So a manually operated double row vegetable planter was conceived and to enhance planting effectiveness and diminish drudgery associated with manual planting method. Seed planting is additionally feasible for various sizes of seed at variable depth and space between two seed.

Owing to these reasons, the "**Development of manual operated double row vegetable seed planter**" has been taken up. Taken care to ensure that the cost of the machine, functioning and safeguarding cost were low. Also diminish the weight of the machine to increase the productivity of crop. This machine is easy to use and less effort required as compared. It is helpful for small scaling farming.

Objectives:-

1. To develop double row manually operated vegetable planter for suitable vegetable seeds.

2. To test and evaluate the performance of the developed planter.

3. To workout operational cost of planting.

CHAPTER II

REVIEW OF LITERATURE

This chapter deals with the past research work done in the most relevant topic of our research. The information of published work on seed drills/planters used for planting of various crop along with different design aspects in discussed in this chapter.

The review and information related to the study are presented under the following heads:

- General
- Seed metering mechanism
- Performance of planter for different crops
- Evaluation of existing seed drill
- Push/pull strength of agricultural workers

2.1 General:

Dash et al. (2003) built up a two- row manually drawn multi-crop drill for small seeds and assessed in the research center and field condition. The developed drill had two modular units. It was assessed in research center with jute and mustard seeds however for field assessment just mustard seeds were utilized. Generally operation of the new drill was observed to be reasonable in lab condition for both the yields. It required just 4 kg of mustard seed to sow one hectare of land at recommended depth and row separating. The new seed drill required just 8.0 kg of draft for its activity. This was inside the limit of a normal man. Seed distribution efficiency and field efficiency of this drill were 84.3% and 67.0%, individually. One hectare of land could be sown by this drill just in 13 hours.

Bozdogan (2006) detailed consistency of seeds in accuracy seeders research facility analyze by assessing three vacuum precision seeders in lab to evaluate seed distribution conveyance inside line. Seed separating consistency was resolved in three inside line separations which were at 14, 17 and 20 cm. the seeders were worked at ground speed 1.8, 3.6 and 5.4 km/h and seed separating over greased belt were estimated. Miss index (MI), multiple index, quality feed index (QFI) and precision index were utilized for assurance of seed dividing consistency of seeders. The outcomes demonstrated that there was huge diverse at $p< 0.01$ level among various, and QFI list. Working speed influenced the seeders miss index, it shifted from 13.36 to 17.36 %. The best QFI, MI, multiple index and precision index was observed to be 0.96, 2.32, 14.44 and 96.72, separately 1.8 km/h working pace. This working rate, was measurably unique in relation to others at $p< 0.10$ dimension of the least miss index, numerous, precision index and the highest QFI esteem were resolved at 1.8 km/h. after 3.6 km/h, the estimations of miss index were changed definitely and best estimation of accuracy record made at 20 cm dividing was acquired as 13.36.

2.2 Seed Metering Mechanism

Sahoo and Srivastava (2011) reported that seed pattern characteristics of different metering systems for soaked okra seed. The average spacing for vertical roller, horizontal plate, horizontal plate (edge drop) with cell size 10 percent more than the maximum seed dimensions was close to the theoretical spacing. The average spacing was close to theoretical spacing with the cell size equal to the maximum seed dimensions in the case of the inclined plate. Feed index quality was strongly affected by the metering systems, cell size and cell speed. Feed index quality decreased with increased speed. However, only a 5 percent decrease in feed index quality was observed with the rise in cell speed to 14 rpm. The speed of the cell mostly affected the multiple Index, miss index and degree of variation. The seed damage followed by cell speed was mainly affected by the metering system. It was noticed that the incline plate metering system was the best for planting okra seed.

Reddy and Adake (2013) developed and tested horizontal rotor seed metering plate system under lab (2.5, 3.5 and 5 km/h) and field conditions. The nature of feed file of the planter went from 85 to 90.5 and 82.7 to 97 %, obviously showed the repletion dispersion of seeds with in space intervals > 10 to <30 cm.

the even rotor metered 85 to 93 recurrence percentile seeds inside 15 to 30 cm separating intervals at task paces of 2.5 to 3.5 km/h.

2.3 Performance of Planter for Different Crops

Maheshwarr and Verma (2007) evaluated the performance of manually operated garlic planter. The speed of planter was 1.8 km/h. The field capacity and field efficiency of planter were 0.0181 ha/h and 78 % respectively. The average plant population of garlic sown by planter and by traditional method were 65 plants/m^2 and 75 plants/m^2 respectively. The germination per cent of garlic after 10 days of sowing by manually operated garlic planter and by traditional method were 69.6 % and 75.6 % respectively. The average yield by manually operated garlic planter and manual planting were 60.83 q/ha and 64.68 q/ha respectively.

Nare *et al.* (2014) designed and evaluate the Self Propelled Garlic (Allium Sativum L.) Clove Planter. At a speed of 1.8 km/h, the theoretical field capacity (TFC) was measured as 0.081ha/h, while the actual field capacity (AFC) was found to be 0.065 ha/h with a field efficiency of 79.84%. It was found that the placement of garlic cloves was between 4.2 cm and 5.2 cm at a uniform depth, with a minimum SD and CV of 0.33 cm and 6.92 percent, respectively. It was found that the miss index, multiple index and seed damage were only 2.67%, 8.0% and 1.46% respectively, which was within an acceptable limit. The machine's operating cost per hour was estimated as Rs.151.00/h. The planter cost 2,321.50 Rs./ha for sowing one ha of field, which was much less than the manual dibbling process, which required 65 man days and 2,878.00 Rs./ha extra. Thus, the newly developed machine saves 55.35 % of money over traditional methods.

Ani O.A. *et al.* (2016) designed and evaluate a vertical plate maize seed planter for gardens and small holder farmers. Planter has a metering efficiency of 88.94%, effective field capacity of 0.27ha/hr and field efficiency of 71.86%. The time required to plant one hectare of farmland was determined as 3.7 hours. The average number of seeds planted per stand was determined as two and percentage seed damage was determined as 1.71%. This planter is considered economical, requiring no special skill to operate and can be adopted for maize planting by small holder farmers.

Shubham Shravan *et al.* (2019) designed and evaluate the performance of manual operated single row vegetable planter for okra, coriander and cowpea crop. The planter consist of power transmission system, seed box, frame, drive wheel, support wheel, furrow opener, metering mechanism for seed, delivery tubes etc. The seeds of “Kashi Kanchan” variety of cowpea, “Pant Haritama” variety of coriander and local variety of okra were selected for the tests. For okra TFC was found to be 0.125 ha/h, similarly for cowpea and coriander TFC was found 0.112 ha/h and 0.05 ha/hr respectively. The actual average travelling speed of operation of the developed vegetable planter was found 2.4 km/hr. It was found that Effective Field Capacity for okra, cowpea and coriander were 0.104, 0.093 and 0.039 ha/h respectively. Field efficiency was determined from the value of TFC and EFC for each crop. It was found that the field efficiency for okra was 83.2%, for cowpea it was 83.03% and for coriander it was found 78%. The cost of developed vegetable planter was found 5930 Rs.

2.4 Evaluation of Existing Seed Drill

Ghosal and Pradhan (2014) developed a low cost manually operated multi crop seed drill with cup feed metering mechanism for small and marginal farmers. The dimensions of cup i.e. 6 mm x 2.89 mm was found to be best and was used successfully up to a peripheral speed of 18.84 m/min. The actual field capacity and field efficiency of the seed drill were 0.063 ha/h and 78.75 % respectively. A net savings was 1780 per ha for green gram in comparison to the local traditional practice. This seed drill costing of 1850 and total operating cost of 13.85 per hour to solve the problem of line sowing of seeds particularly for the small and marginal farmers to enhance production and productivity.

Vignesh *et al.* (2017) designed a vegetable planting machine and concluded that The average plant height, number of branches per plant, plant mortality, yield/m^2, seedling missing, and leaf area index was found more by machine transplanting while plant population was found less by machine transplanting. Time saving, labour saving, less cost of operation were achieved in machine transplanting as compare to manual transplanting.

Elijah *et al.* (2018) developed a self-propelled multi-crop two rows precision planter. Using a 2.2 kw petrol engine as the prime mover. The investigations involved three levels of speed of 4.10, 6.14, and 8.25 km/hr in order to establish the best working speed for the machine. Best field performance of the planter was obtained at 8.25 km/hr working speed with a field efficiency of 81.2%, minimal seed damage and field capacity of 0.1 ha/hr.

Nandede e*t al*. (2018) developed a manually operated single row millet planter cum fertilizer drill. Slot size of 3 x 3 mm was found to be suitable for kodo millet as it delivered optimum average seed spacing (ASS), seed rate (SR) and coefficient of uniformity (Uc) as 5.90 cm, 4.50 kg/ha and 0.90, respectively. For little millet also, 3 x 3 mm slot size on vertical rotor plate provided optimum ASS, SR and Uc as 5.70 cm, 2.24 kg/ha and 0.82, respectively. No seed damages were observed with any of the selected plates. Vertical plate with 10 × 10 mm slot size at 40% opening of shutter was found suitable for fertilizer metering for both crops. The implement field capacity and field efficiency was found to be 0.048 ha/h and 69% for kodo and 0.05 ha/h and 68% for little millet, respectively. Seed saving with developed planter-cum-fertilizer drill as compared to traditional method of line sowing and broadcasting was found to be 76% and 90%, respectively for kodo; for little millet, it was 83% and 93% respectively. The cost of operation was found to be 750/ha for kodo and 662/ha for little millets. Yield obtained with developed planter-cum fertilizer drill were 1870 kg/ha and 1560 kg/ha which was to 139% and 51% more when compared with broadcasted kodo and little millet respectively.

Vinod kumar *et al.* (2018) designed a Manually Operated Ridge Vegetable Planter which consisted of the seed metering unit, seed box, speed reduction unit, handle, seed tube and tyne. Since seeds of different crops vary in size and shape, it is important to adjust the size of the cell of the seed metering roller. It can easily be achieved by replacing the required size of the seed roller. The planter will solve the problem of manually dropping precious seeds of vegetable crops on ridges effectively and will improve the farmer's productivity. The need of a small land holder has fulfilled by the ridge vegetable planter. It can effectively place seeds at acceptable pattern.

Nandini *et al.* (2018) designed a Manually Operated Multi-Crop Inclined Plate Planter for Farm Women and its performance evaluated for planting of Maize, Pigeon pea, Bengal gram, Green gram. Power was transmitted from the drive wheel to metering mechanism through chain and multi sprockets and bevel gears. Inclined plate type metering mechanism was used in the planter. Seeds were placed in the furrows at desired depth and seed to seed spacing through adjustable system. The average depth of Maize, Pigeon Pea, Bengal gram and Green gram was 4.6, 3.83, 4.17 and 4.21 cm and seed to seed spacing was 22.7, 19.2, 12.6 and 11.47 cm respectively. For planting Maize, Pigeon Pea, Bengal Gram and Green Gram, the multi crop planter has an average forward speed of 2.7 km/h. The handle was made to be flexible for the varying heights of males and females. Within the hollow M.S tubing, the adjustable handle length was 148cm and 40cm of mild steel round bar was bolted. The cost of the manually operated multi crop planter was approximately rupees 4460 which is the within buying capacity of the formers of the India.

2.5 Push/Pull Strength of Agricultural Workers

Biman and yanquing (2004) decided the isometric force and push quality profiles of males and females were in seated and standing position in workspace. The most grounded force quality area was at extraordinary reach vertically over the shoulder for the two males and females. The best force strength of 400 Newton’s (N) for males was recorded in the seating and standing positions. Females pull qualities in the seated and standing positions were 222 and 244 N, separately.

CHAPTER III

MATERIALS AND METHODS

A manually operated double row vegetable seed planter was developed and fabricated under this investigation at our college workshop. The fabricator was given drawing and design of the machine and monitoring was done during the fabrication. Both the field and laboratory experiments were conducted to study the performance evaluation of planter for seeds like okra, dolichos bean, pea, cowpea at the department of horticulture, precision farming and development centre, college of agriculture, IGKV Raipur Chhattisgarh during the year 2019-20. The details of materials used, experimental methodology and measurement techniques adopted during the course of investigation were described in this chapter.

3.1 Design Parameters of Farm Machinery:

A farm machinery design engineer must consider the following factors before designing the machine:

1. Power requirement of machine and power availability.
2. Functional requirement of machine and its interrelationship of various components.
3. Optimum expected life of machine; working life 2000 hrs.
4. Strength requirement of various components.
5. Material substitution and selection based on analysis of forces, market availability of raw material.
6. Wear characteristics of component.
7. Ease of operation of various component of machine.
8. Reliability of components and the machine.
9. Possibility of designing a multipurpose machine combining more than one function into a single machine.
10. Cost of machine and farmer’s paying capacity.
11. Economy commensurate with its quality.
12. Ease of operation and adjustment of machine and its maintenance.
13. Safety aspects.

14. Human factors in design.
15. Aesthetic appeal and durability of the machine.
16. Cultural requirement of the community for exportable produce.
17. Suggestion and feedback from the users.
18. Other competitive product in the market.

3.2 General Design Considerations of Vegetable Seed Planter

The designed vegetable planter should have following important features for its satisfactory performance at the user level:

3.2.1 Functional consideration/ Requirements:

The functions of a well designed seed drill or planter are as follows:

1. Meter seeds of different sizes and shapes.
2. Place the seed in the acceptable pattern of distribution in the field.
3. Place the seed accurately and uniformly at the desired depth in soil.
4. Cover the seed and compact the soil around it to enhance germination and emergence.

3.2.2 Agronomical consideration:

Following agronomical requirements were also considered for design of machine:

Table 3.1: Agronomical requirement of selected seeds

Crop	Seed rate in kg/hac	Plant to plant distance in cm	Row to row distance in cm
Okra	12-14	30	60
Cowpea	15-20	30	50
Pea	150	20	30
Dolichus bean	30-40	30	40

3.2.2 Economical consideration:

1. The cost of the planter should be as low as possible so that, small farmers can afford to purchase the machine.
2. The quality of work done by the planter should be best possible with minimum cost.
3. The parts of planter should have adequate strength.
4. The material of construction of different components should be easily and locally.
5. Maintenance cost should be low.

3.3 Design of Manually Operated Planters

Manually operated vegetable planters are basically a hand wheel hoe, used for inter-culture operation on which planting mechanism is mounted. The planting mechanism consists of a vertical plate with spoons, and receives drive motion from the ground wheel through chain and sprockets.

3.4 Construction Details of Vegetable Seed Planter

The vegetable seed planter consists of following parts:

1. Main frame
2. Seed hopper
3. Seed metering mechanism
4. Power transmission system
5. Handle
6. Furrow openers
7. Seed rate adjusting lever
8. Transport wheel

3.4.1 Power developed by the operator:

According to Campbell *et al* (1990) the power of useful work done by human being is given by: -

$$HP = 0.35 - 0.092 \log t$$

Where t = time in minutes

To operate the manually operated seed planter for 3-4 hours continuous work the power developed by the operator would be 0.10- 0.13 hp say 0.11 hp.

We know that

$$\text{HP} = \frac{\text{push (kgf)} \times \text{Speed (m/s)}}{75}$$

Let the operating speed of the machine 0.69 m/s *i.e.* 2.5 km/h.

Therefore,

$$\text{Push (kgf)} = \frac{\text{HP} \times 75}{\text{Speed (m/s)}}$$

$$= \frac{0.11 \times 75}{0.69}$$

$$= 11.95 \text{ kgf} \approx 12 \text{ kgf}$$

Hence, force developed by an average human worker = 12 kgf

3.4.2 Size of the planter

Size of the manually operated vegetable seed planter was determined using the following formula (Sharma & Mukesh, 2010)

Z = D/d

Where,

Z = number of furrow opener in the planter

D = draft of the planter, kgf

D = draft of each row, kgf (12-15 kgf for shallow depth)

Working width of machine would be

W = Z × a

Where,

W = working width of the planter, cm

a = row to row distance, cm (depends on the crop type)

Size of the double row vegetable seed planter is estimated 60 cm. row to row spacing is taken 30 cm and number of furrow opener is two.

3.4.3 Main frame

The main frame assembly was made of ϕ 30 mm m.s. pipe. It supports seed box and furrow opener. Total length of main frame is 1400 mm.

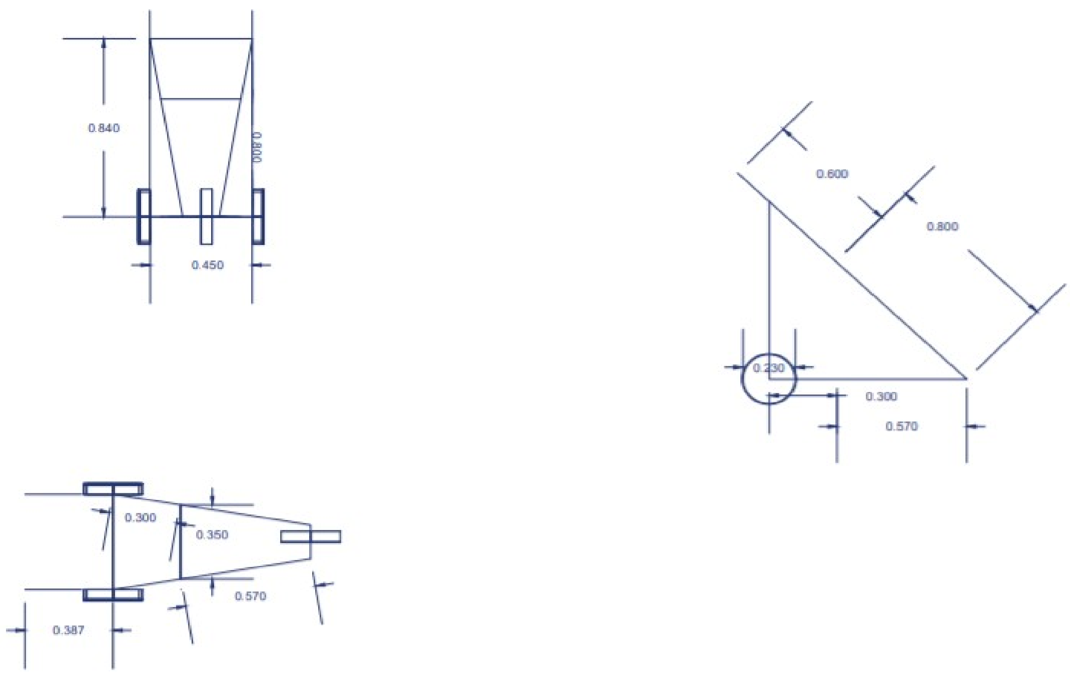


Fig 3.1: - Isometric view of main frame of vegetable planter.

a) Front view b) side view c) Top view

3.4.4 Design of handle

A standard light weight m.s. 30mm diameter conduit pipe is used for handle of the tool carrier. Length of handle is calculated based on average standing elbow height of female operators.

Average standing elbow height of female worker = 100 cm

Distance of wheel center from the operator (for operator height of 95-105 cm) in operating condition = 115 cm.

Therefore, angle of inclination (θ_h) with the horizontal

$$\tan \theta_h = 80/115 = 0.696 \text{ or } \theta_h = 35^o$$

so in order to accommodate 5-95% of operators, a 30 mm outer diameter conduit pipe of 140 cm long is used for handle whose operating height cam be adjusted from 95 cm to 105 cm from the ground. A plastic hand grip of 30 mm dia., 215 mm long is fitted at the end od conduit pipes for easy grip and operation of the machine.

3.4.5 Seed hopper

Seed hopper consisted of seed box, metering shaft circular plate with cells, seed tube mounting pipe. Seed shape and size are taking into consideration while designing the seed hopper. Other than shape and size of the seed, angle of repose, coefficient of friction between hopper and the seeds and application rate are also consider in seed hopper design.

The volume of seed hopper box is calculated by measuring all the sides of seed hopper. The capacity of box was determined by keeping the balance between the weight of material filled (as it affects draft) and the field efficiency of the machine. Application rates and field capacity values had to be taken into consideration.

The volume of seed hopper box was calculated 53.58×10^{-4} m^3. Capacity of box is calculated by

$$V = \frac{Q1}{\rho}$$

Where,

V = Volume of box, m^3

Q1 = Box capacity, kg

ρ = Bulk density of material, kg/m^3

Table 3.2:- Bulk densities of different crops

S. no.	Crop	Bulk density kg/m3
1	Cowpea	570
2	Okra	550
3	Pea	600
4	Dolichos bean	700

Sources: - FAO/ INFOODS Density Databases

The capacity of seed hopper box was found to be 3.05 kg for cowpea, 2.94 kg for okra, 3.21 kg for pea and 3.75 kg for dolichus bean.

Fig 3.2: - Isometric view of seed hopper a) Top view b) side view

3.4.6 Seed metering mechanism

Metering mechanism is the heart of sowing machine and its function is to distribute seeds uniformly at the desired application rates. In seed planter it also controls seed spacing in a row. A seed planter may be required to drop the seeds at rates varying across wide range. The cells on the vertical rotor were placed at the outside edge of the rotor. The seed was picked up in each cell from the hopper and then drop into the seed tube. Separate rotors with different cell sizes could be used for different crops. The seed metering mechanism was comprised of the following component:

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

3.4.6.1 Seed rotor

A plastic moulded rotor of 96.5 mm diameter 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 rotor body was split out and another rotor was to be placed in the body. Separate rotor 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 planter is to be used for sowing of okra, cowpea, dolichus bean and pea. The number of cells to be kept for a particular crop was computed by using formula:

$n = \pi D/ix$

Where,

n = Number of cells on the rotor.

D = diameter of the ground wheel in cm (40 cm for cycle wheel)

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

x = required seed to seed spacing (60 cm, for okra)

Putting the values:

$$n = \frac{40 \times \pi}{60 \times 1}$$

$$n = 2.09$$

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.

Table 3.3: - Number of cells on rotors for different crops

S. no.	Crop	Recommended plant to plant spacing (cm)	Number of cells on periphery of rotor
1	Pea	30	4
2	Okra	60	2
3	Cowpea	60	2
4	Dolichus bean	60	2

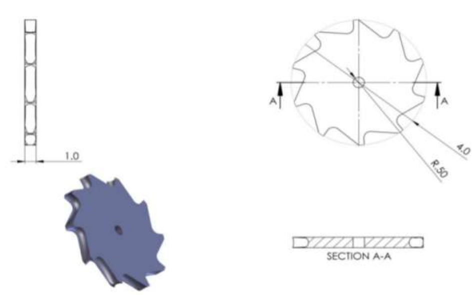


Fig. 3.3: - Isometric view of seed rotor

a) side view b) front view c) Isometric view

3.4.6.2 Seed rotor cover box:

The seed rotor was fitted inside the rotor body. This body could be part in two sections by methods for a pivot arrangement, with the goal that the rotor could be expelled and supplanted by another effectively. The upper half bit of body was fitted to the seed box with nut and fastener where a rectangular space was given. The lower half part of body was pivoted toward one side and having nut and fastener plan at the opposite end with the goal that the lower half segment of body could be effectively part 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 diameters. The seed tube was mounted on this discharge chute for carrying the seed to the boot of furrow opener.

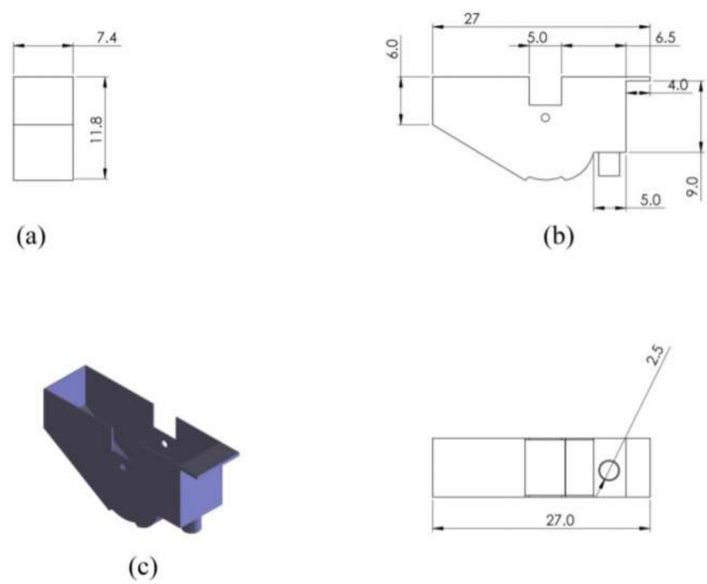


Fig. 3.4 a) & b) Side view of seed rotor cover box c) Isometric view

3.4.6.3 Seed rotor shaft

The two seed rotor cover box was connected by single shaft with having square section in the middle of length of each seed rotor cover box. The rotor shaft of 16× 16 mm was made of m.s. bright bar. The length of the shaft 450 mm and was having a square section. The remaining two sides for each cover box were made of round section of 15 mm diameter so that the shaft could be supported in two bush bearing of 15 mm size having 25.4 mm length each.

3.4.7 Power transmission unit

The power transmission unit consisted of the following components:

1. Ground wheel
2. Power transmission shaft
3. Chain and sprockets arrangement

3.4.7.1 Ground wheel

The ground wheel was made up of 25×4 mm MS flat having length 116cm by bending in circular shape and 17 triangular pegs were welded at the periphery of the wheel for better griping with soil. The ground wheel was provided on the front side of the frame which formed the functional component of power transmission unit. The rotation of ground wheel caused the rotation of vertical rotor through chain and sprocket arrangement. The effective diameter of ground wheel was 35 cm.

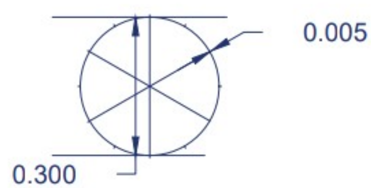


Fig. 3.5 Front view of ground wheel

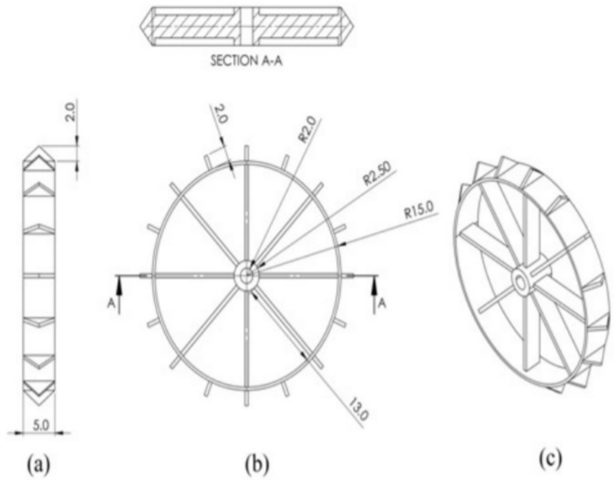


Fig.3.6 a) side view b) front view c) Isometric view of ground wheel

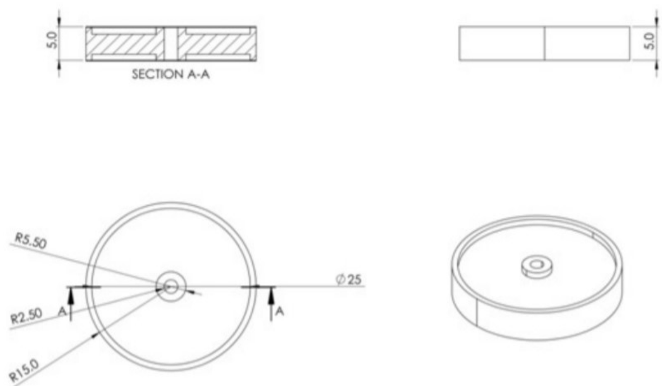


Fig. 3.7 Isometric view of support wheel

3.4.7.2 Power transmission shaft

The power transmission shaft was supported in two bush bearing fitted to the main frame. It rotated inside bush bearing 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 numbers of teeth was mounted on this shaft to transmit power from ground wheel to rotor shaft.

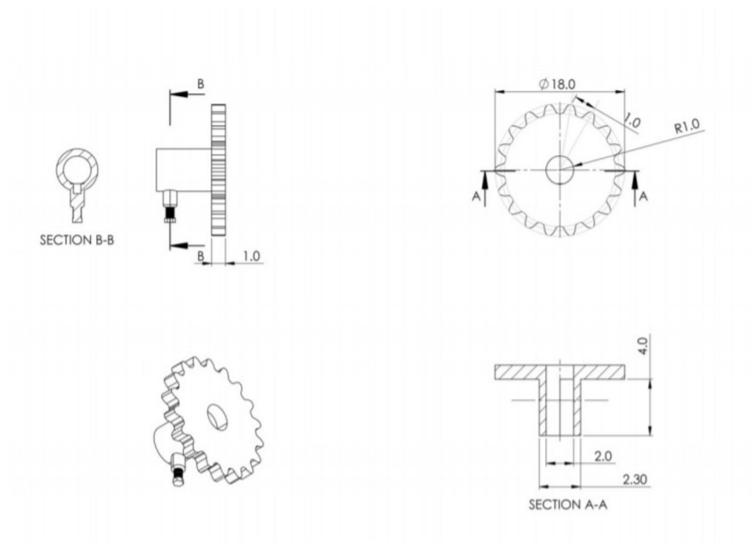


Fig. 3.8 Gears of transmission system

3.4.7.3 Chain and sprocket arrangement

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 sprocket 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 12.7mm suitable chain was used to connect the two sprockets.

3.4.7.3.1 Design of chain drive:

A standard roller chain with 15mm pitch commonly used in cycle is selected for transmission of power. The length of chain is calculated by following equation:

$$m = \frac{2C}{p} + \frac{Z1+Z2}{2} + \frac{(Z1-Z2)^2}{2\pi p}$$

Where,

m = number of chain links

C = center to center distance between two sprockets (mm)

Z1 = number of teeth in driver pulley

Z2 = number of teeth in driven pulley

P = chain pitch, mm(15 mm in present case)

Putting the values in the above equation we get

$$m = \frac{2 \times 400}{15} + \frac{18+1}{2} + \frac{(18-1\ )^2}{2\pi \times 15}$$

= 71.33 or 72 (say)

Now, chain length (L) is given by

$L = m \times p$

$= 72 \times 15 = 1080$ mm

3.4.8 Furrow opener

The optimum depth of planting varies widely with different crops and is influenced by soil moisture conditions, soil temperature, time of year, etc. Some seeds are rather sensitive to environmental conditions and require careful control of the planting depth, whereas others can tolerate a considerable range of conditions.

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 and welded with the opener of high carbon steel. A plastic pipe of 28 mm diameter and 100 mm length was clamped at the rear of furrow opener for dropping the seed through it. It is assumed that the draft force on furrow opener is 15 kgf/tyne. It was acting height h/3 from bottom of furrow opener. Maximum height of furrow opener tyne is taken as 20 cm.

Distance of draft application on furrow opener tyne is:

$a = h/3$

$= 20/3 = 6.66$ cm

Moment arm length = (h-a)

= (20-6.66)

Bending moment on tyne = D x (h-a)

= 15 kg x 13.34 cm

= 200 kg-cm or 20000 N-mm

Take factor of safety = 2

Therefore, maximum bending moment in tyne

= 20000 x 2 = 40000 N-mm

Also section modulus of tyne (Z) = M_b x f_b

= 40000/56 = 714.2 mm^3

Take b = 20 mm size flat

t = thickness, mm

z = (1/6) t b^2 (for rectangular section)

t = 6 x 714.2/400 = 10.7 mm

So M.S. flat tyne 20 x 10 mm size is safe for furrow opener. But in market 35 x 10 mm flat is available which is selected for furrow opener of the machine. Two furrow opener is taken for double row vegetable seed planter of same size.

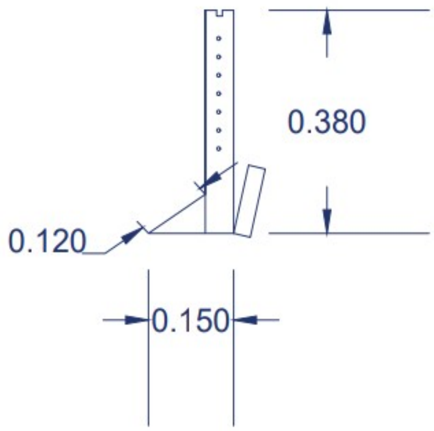


Fig. 3.9 Design of furrow opener

3.5 Working of the Metering Mechanism:

The cup feed metering device was used for metering different size and shapes of seeds. The metering mechanism for seed consisted of standard plastic cup feed seed metering unit. Seed metering rollers were attached or fixed on mild steel solid square shaft size 20 x 20 mm rod and length of 450mm. Two seed box is taken for double row seed planter and attached with the single shaft with square section in the middle of the each seed box. The shaft attached inside the rollers through which the rotating action action of roller occurs. Rotation of roller in housing, filled with seeds causes the seeds to flow out from roller housing in a continuous stream. The seed rate can be adjusted by adjusting scale controlling exposed length of flutes, depends on the scale which is in contact with seed; fairly accurate seed rate can be achieved for a variety of different size seeds like okra, cowpea, pea and dolichos bean.

Controlling seed between metering device and furrow:

Precise metering is of little value unless the seeds are controlled so that each requires the same time from the meter to the furrow and unless bouncing and rolling in the furrow are minimized. Variations in drop time can be minimized by one of the following:

1. Having a short, smooth, small-diameter drop tube with the discharge end close to the bottom of the furrow.
2. Discharging the seed directly from the metering device within a few centimeters of the furrow bottom.
3. Mechanically transferring the seed from the metering unit to the furrow as is done with transfer wheels on some hill drop planters.

Slow cell speeds, or trajectory- shaped seed tubes for high plate speeds minimize bouncing within the seed passage.

Seed movement in the furrow can be minimized by having a narrow furrow and by imparting a rearward velocity component to the discharged seed to at least partially offset the forward velocity of the planter.

3.6 Fabrication of the Machine

Solid works design and drawing was used for the design, development and fabrication of the double row vegetable seed planter. The different components of the planter mentioned in previously described subheadings were fabricated and assembled.

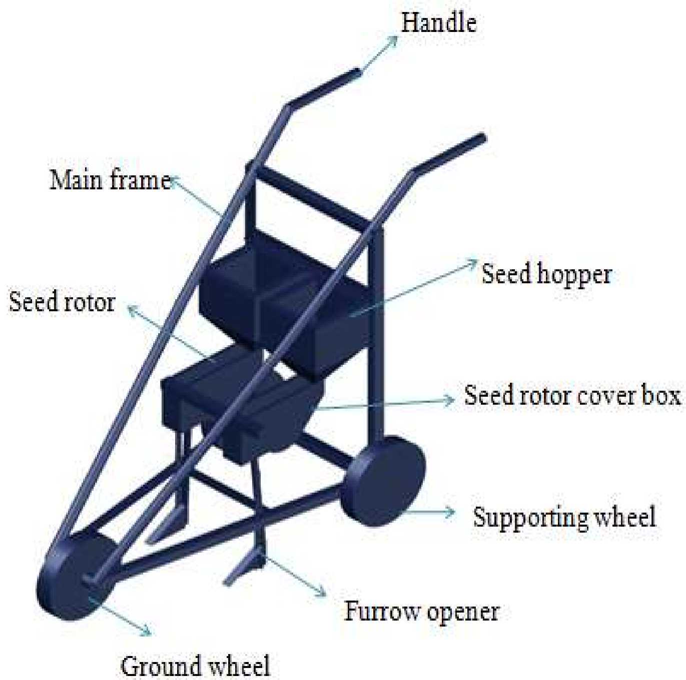


Fig.3.10 Isometric view of developed double row vegetable seed planter

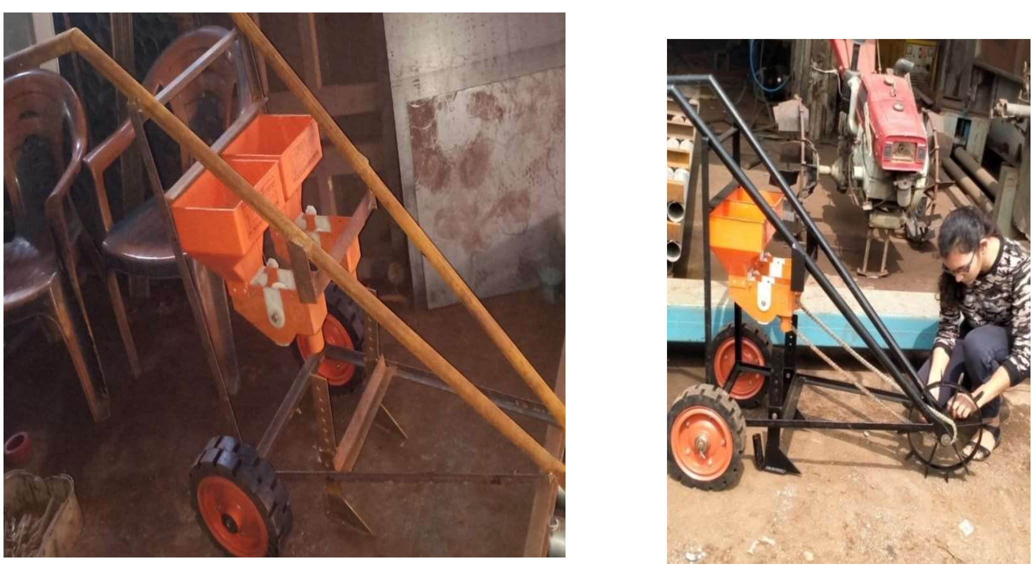


Fig.3.11 Fabrication of vegetable planter

Fig. 3.12 Developed manual operated double row vegetable seed planter

3.7 Test Procedure:

The method of testing the performance of operation and soundness of construction of planter is taken from Indian standard test code for sowing equipment. Testing of the planter was done as per the guidelines of the procedure suggested by the Regional Network for Agriculture Machinery (RNAM, 1985), Testing and Evaluation of Farm Machinery (Mehta & Verma 1995) and Indian Standard Test Code for Sowing Equipment (IS 6316:1993). 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.

3.7.1 General test

3.7.1.1 Checking of specifications

Specifications of the double row vegetable planter were checked after the development of the planter with the standard given for their accuracy.

3.7.1.2 Checking of material

The material used to develop double row vegetable planter was checked to avoid wear and tear for each and every component and found to be same as the specifications.

3.7.1.3 Visual observations and provision for adjustment

The developed double row vegetable planter was visually observed and necessary adjustment such as depth of furrow opener was adjusted.

3.7.2 Laboratory tests

3.7.2.1 Theoretical Seeding Rate (R_{st})

The number of vegetable seeds planted per hectare was calculated by using the following relationship.

$R_{st} = 10^8 / (W \times Xs)$................... (1)

Where,

R_{st} = Theoretical seeding rate (seed ha-1);

W = Row width (cm); and

Xs = Seed spacing along the row (cm).

3.7.2.2 Seeding Mass Rate (R_{sm})

The total mass of seeds planted per hectare expressed in Mg ha-1 was calculated by using the following relationship.

$R_{sm} = [M / (W \times Xs)] \times 100$ ......(2)

Where,

R_{sm} = Seeding mass rate, (Mg ha-1);

M = Average mass of one seed;

W = Row width (cm); and

Xs = Seed spacing along the row (cm).

3.7.2.3 Seed metering test

Laboratory calibration is required to check correctness of seed dropping rates / to examine the performance of metering mechanism. The procedure is as follows:

Materials required for calibration

a) Seeds required completing tests at full, three fourths, one half and one fourth capacity of the hopper level.
b) Weighing balance to weigh the seeds.
c) Tape
d) A chalk to mark at one place on the drive wheel of the planter.
e) Cotton cloth bags or plastic bags to collect the seeds coming out from each of the seed cup.
f) Two jacks or wooden blocks for jacking up the machine above the ground, so that drive wheels could be rotated freely.

Procedure for calibration

1. Measure the distance between two furrow opener.
2. Effective working width of drill:

   W = $\frac{N\ x\ d}{100}\ meter$

   Where N = number of furrow openers

   d = distance between two adjacent furrow openers (centimeters)

3. Circumference of the driving wheel (L):

   Measure the diameter of the wheel (cm) = D

   Circumference of the wheel (L) = $\frac{22\ x\ D}{7\ x\ 100}\ meters$

4. Area sown in one revolution of the drill (A):

   A = W x L square meter

5. Number of revolutions required to sow one hectare (R):

   $R = \frac{10000}{A}\ revolutions$

6. Number of revolutions actually required to cover one hectare. Considering 10% wheel

   Slip (M):

   $M = \frac{R\ (100-10)}{100}\ revolutions$

7. Seed rate to be sown per hectare = P Kg (say)

8. Seed quantity required for one revolutions (S):

   $S = \frac{Seed\ rate\ (kg)}{No.of\ revolutions\ required\ to\ sow\ one\ hectare}$

   $= \frac{P\ X\ 1000}{M}$ = G gm (say)

9. Seed quantity required for 20 revolutions:

   G x 20 = B gm (say)

10. After the above calculations, prepare the drill for calibration in the following manner.

    a) Jack up the seed drill: Remove the tubes from, the feed cup in their place tie plastic or cotton bags to collect the seed and fertilizer. The bags should be numbered. The bags should be numbered.
    b) Mark with chalk on drive wheel to count the number of revolutions.
    c) Rotate the drive wheel 20 times at normal field speed.
    d) The seeds of all the bags be collected in one big bag and weigh it.

(a) (b)

(c) (d)

Fig.3.13: - (a), (b), (c) and (d) Calibration of vegetable planter

3.7.2.4 Seed damage determination test

The test is conducted to see the visual damage caused to the seeds passing through the metering device. Take seed samples of known quantity (let one kg) from each sack and label with test number, opener and rate setting. The dropped seeds obtained after passing through the metering shall after 20 revolution of drive wheel were collected and sorted out into two lots viz., undamaged seeds and damaged seeds. Count the number of seeds with visible damage. Take the mass of the damaged seeds and calculate the percentage of damaged seeds before and after the test. The percentage of damaged seeds was calculated by following formula:

$$\text{Damaged seeds percentage} = \frac{\text{weight of damage seeds}}{\text{total weight of dropped seed}} \times 100$$

3.7.2.5 Effect on seed discharge rate due to different forward speeds

The difference in seed discharge rate would be assessed by using recommended seeds and variation in discharge at three different speeds shall be recorded. The variation in seed discharge due to different speed should not be more than 15%.

3.7.3 Field test

The testing of the developed double row vegetable seed planter for okra, pea, cowpea and dolichos bean planting was conducted at the farm of department of precision farming development center, college of agriculture, IGKV Raipur. This testing was conducted in the field of 0.1 ha with 3 replications in Randomized blocked design (RBD). During the test, various parameters related to soil, crop and performance of planter were studied and the data was recorded. They were presented as under:

3.7.3.1 Moisture content of soil

Moisture content of soil was measured by oven drying method. The soil sample was selected randomly at five places in the field and weighed. All five samples were kept in an oven at 105^{o} c for 24 hours. After 24 hours samples were taken out and weigh the dry weight of soil. Moisture content of soil was calculated by using following formula:

$$M_{db} = \frac{\text{weight of wet soil sample} - \text{weight of oven dry soil sample}}{\text{weight of oven dry soil sample}} \text{ x } 100$$

$$M_{db} = \frac{w2 - w3}{w3 - w1}$$

Where,

M_{db} = Moisture content in % dry basis.

W1 = Weight of container in grams

W2 = Weight of container + Weight of moist soil, in grams.

W3 = Weight of container + Weight of oven dry soil, in grams.

Fig.3.14 Soil sample collection

Fig.3.15 Determination of moisture content by oven drying method

3.7.3.2 Bulk density of the soil

Bulk density of the soil is the mass after oven drying of soil of a unit volume. For measurement of bulk density of soil, a cylindrical core cutter is taken and soil samples are collected from at least three locations randomly in the test plot. The diameter and length of the cylindrical soil sample is measured. Kept the core samples in a oven and maintained temperature 105^{o}c for at least 8 hours. At the end of the 8 hours, took out the samples from the oven and cool them in a desiccators and weighted in a electronic weighing balance. The bulk density of soil is calculated by following formula:

Bulk density of soil = $\frac{M}{V}$

$$= \frac{4\,M}{\pi D^2 L}$$

Where,

M = Mass contained in core sample of oven dry soil

V = Volume of cylindrical core sample

D = Diameter of cylindrical core sample

L = Length of cylindrical core sample

3.7.3.3 Field shape and size

Shape and size of the field is measured with the help of steel tape length of 30 meter. Size should not less than 0.1 ha in case of manually operated machines/ animal drawn machine (IS 6316:1993). Randomized block design in the field with plot size of $4m^2$ is marked and taken three replications of each crop.

Fig.3.16 Randomized block design in field

Fig. 3.17 Field preparation

3.7.3.4 Seed to seed and row to row spacing

Plant to plant spacing maintained by seed metering mechanism of the vegetable planter was measured carefully with the help of steel tape or scale. After the observation and measurement is taken, average seed to seed spacing was calculated.

Row to row distance is the distance between two furrow opener which is fixed and previously measured. After the sowing operation row to row spacing is also measured with the scale. After the measurement is taken average row to row spacing was calculated.

Fig. 3.18 Plant to plant spacing

Fig. 3.19 Row to row spacing

3.7.3.5 Depth of seed placement

Depth of seed placement was measured using scale. For this ten random observations were taken and average was calculated. For different crops, desired depth of the seed placement can be obtained by adjustment made in the furrow opener.

Fig. 3.20 Depth of seed placement

3.7.3.6 Miss Index (MI)

Skips or misses are created when seed cells fails to pick up and deliver seeds to the drop tubes. The missing percentage is presented by an index called the Miss Index (MI) (Bakhtiari and Loghavi, 2009) which is the percentage of spacing greater than 1.5 times the theoretical spacing. Smaller values of MI indicate better performance.

3.7.3.7 Multiple Index (DI)

Multiples are created when more than one seed is delivered by a cell. The multiples percentage is represented by an index called Multiple Index (DI) (Bakhtiari and Loghavi, 2009) which is the percentage of spacing that are less than or equal to half of the theoretical spacing. Smaller values of DI indicate better performance.

3.7.3.8 Coefficient of Variation (CV)

This represents the overall difference between the actual and nominal seed spacing in a percentage along a randomly selected for 5 rows of 2 m length of each planted row (Bakhtiari and Loghavi, 2009).

$$CV\ \% = \{[\sum (|D - L1) + |D - L2| + ... |D - Ln|)] / (n \times D)\} \times 100 \quad (3)$$

Where,

D = Nominal seed spacing, mm;

L = Actual seed spacing, mm; and

n = Total number of seed spacing measured.

3.7.3.9 Theoretical field capacity

The theoretical field capacity of an implement is the rate of field coverage that would be obtained if the machine were performing its function 100% of the time at the rated forward speed and always covered 100 % of its rated width. The TFC can be calculated by using formula:-

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

3.7.3.10 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.

3.7.3.11 Actual operating hours

It was the time during which the machine is actually performing its intended function. The effective operating time per hectare is greater than the theoretical time per hectare if less than the full rated width is utilized. It was recorded by stop watch.

3.7.3.12 Effective field capacity

The EFC is the actual area covered by the implement, based on its total time consumed and its width. It was calculated by following formula:-

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

3.7.3.13 Field efficiency

It is the ratio of effective field capacity and theoretical field capacity expressed in per cent.

$$\text{Field efficiency } (\eta) = \frac{\text{Effective field capacity}}{\text{theoretical field capacity}} \text{ x } 100$$

3.7.3.14 Man- hour requirement

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

3.7.3.15 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. It depends upon the row to row and plant to plant spacing of the crop. It is calculated by following formula:

$$\text{Plant population per hectare} = \frac{1000}{\text{row spacing (m) x plant spacing (m)}}$$

Fig. 3.21 Measurement of number of plant per square meter

3.8 Instrumentation

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

3.8.1 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.

3.8.2 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 2 kg capacity was used to compute the weight of the seed while conduct the calibration test.

3.8.3 Metallic frame

A metallic frame of 1x1 m^2 size was used to measure the plant count and percent emergence.

Fig. 3.22 Germination of okra seed Fig. 3.23 Germination of cowpea seed

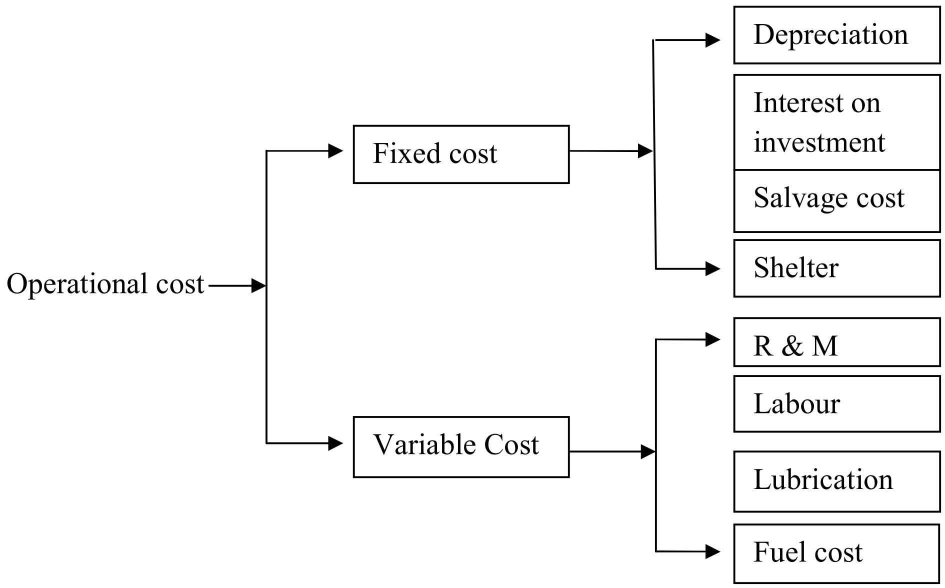
Fig. 3.24 Germination of dolichos bean Fig.3.25 Germination of pea

3.9 Cost Analysis

Farm machinery is characterized by low annual use. Surveys have indicated that, considering the United States as a whole, the average annual use of most field machines seldom exceeds 15 full days. The total cost of performing a field operation includes charges for the fabrication of implement (material used to fabricate the planter) and labor. The operational cost was calculated using available data.

3.9.1 Composition of cost of operation

Implement costs are divided into two categories – fixed costs and variable costs or operating costs. Total operational cost of the machine is the sum of fixed cost and variable cost of the machine.



3.9.2 Total life in hours and years

Total life in hours and years should be assumed before the calculation of fixed cost. Total life in hours of field machines except for tractors are from 1000 to 2500 hour depending on the kind of machine. Total life in years may be decided by the assumed total life in hours and the expected operating hours per year which are introduced as follows: Operating hours per year is assumed with the product of period of working seasons, rate of available working days in the season, working hours per day and rate of actual operating time in the working hour.

3.9.3 Annual fixed cost

Fixed costs are related to machine ownership and occur regardless of whether or not the machine is used. Fixed costs per hour are inversely proportional to the amount of annual use. Fixed cost is the total cost of depreciation, interest on investment and shelter.

a) Depreciation

Depreciation is the reduction in the value of a machine with the passage of time. The straight line method is the most practical and the most common method to calculate depreciation. It is the simplest method and gives a constant annual charge for depreciation throughout the life of the machine. Depreciation is the loss of value of a machine with the passing of time.

$$D = \frac{C-S}{LXH}$$

Where,

D = Depreciation per hour

C = Purchase price,

S = Salvage value, Rs. (Which is 10% of purchase price)

L = Life of machine, year

H = no of operating hours per year

b) Interest on investment

Interest on the investment in a farm machine is a legitimate cost, since money spent in buying a machine cannot be used for other productive enterprises. The rate of interest should reflect prevailing rates. With straight line depreciation, the average investment is equal to one half the sum of the new cost and the trade in or salvage value.

$$\text{Interest (Rs/h)} = \frac{C+S}{2} \times \frac{i}{H}$$

Where,

i = % rate of interest per year = 12 % per year

c) Shelter

Shelter = 1% of purchase price of machine (Rs.)

Total fixed cost per year,

FC = Depreciation + Interest + shelter

3.9.4 Variable Cost

Operating costs are directly related to the amount of use and include repairs and maintenance, fuel and lubricants and servicing.

a) Repairs and Maintenance

Repair costs are difficult to estimate because of wide variation resulting from differences in operating conditions, management, maintenance programs, local costs, etc. The repair and maintenance rate is taken as 6%.

$$\text{Repair and maintenance cost (Rs/h)} = \frac{C \times m}{H}$$

m = repair and maintenance rate 6%.

b) Wages to operator

Wages are calculated on the basis of actual wages of worker.2a

c) Fuel cost

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

d) Lubricant cost

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

Total variable cost, VC = Repair & Maintenance cost + Wages

3.9.5 Total cost of operation

Total cost of operation is the sum of total fixed cost and total variable cost of the planter.

Total cost, TC = Fixed cost + Variable cost

CHAPTER – IV

RESULTS AND DISCUSSION

This chapter deals with the results and discussion of the experiments described in the chapter III in order to fulfill the objectives of the project work. The soil conditions was measured under laboratory of SV college of agriculture engineering and technology & research station, IGKV, Raipur (C.G.) and the performance of the developed machine double row manual operated vegetable seed planter was evaluated at the field of department of precision farming and development center, IGKV, Raipur (C.G.), considering seed rate, effective field capacity, field efficiency and cost of operation. The seeds of local varieties of cowpea, okra, pea, dolichos bean were taken for the tests. Results drawn from the experiment are discussed below:

4.1 Status of Vegetable Production in Chhattisgarh

The home stead garden (0.2ha.) locally known as 'Badi' covers 5% area of total area of Chhattisgarh. The soils of Badi are entisols and inceptisol, fenced, upland and sloppy. Each badi contains one shallow dug well. Most of the farmers having Badi in their backyard and they use to practice vegetable farming for their own consumption. Most of the farmers cultivate Badi by raising vegetables only. But not any suitable seed sowing machine has available for farmers. For growing vegetables they refer indigenous package of practice like indigenous plough, dug well for irrigation. Nowadays Chhattisgarh is growing as big producer of vegetable crops. Area and production of some vegetable crops for the year is shown below:

Table 4.1 Area & production of vegetable crops for the year 2012-13

Sn	Name	Area (km^2)	Percentage (%)	Production (T. MT)	Percentage Production (%)	Productivity (MT)
1	Okra	26796	7.23	264396	5.33	10
2	Cowpea	13272	3.58	208405	4.2	16
3	Green pea	11050	2.98	151963	3.06	14
4	Beans	5219	1.41	52962	1.07	10
5	Cluster beans	4042	1.09	30813	0.62	8

4.2 Laboratory Test of Manual Operated Double Row Vegetable Seed Planter for Selected Crops

4.2.1 Moisture content of the soil

The average moisture content of the soil was measured from five random soil samples from different location of the field was found to be 5.16 % in dry basis. The laboratory data measured are shown in the Appendix A-1.

4.2.2 Bulk density of the soil

Bulk density of test plot soil was found 1.38g/cm^3. Higher value of bulk density of soil restricts root growth of plant. Bulk density was measured with the help of core cutter of known capacity. The soil sample from random five places in the field was taken and calculated. The value of bulk density of soil was in acceptable range, the recorded data are presented in Appendix A-2.

4.3 Testing of Double Row Vegetable Seed Planter for Cowpea Crop

The planter was calibrated in the laboratory for desired seed rate by using the different size rotors, different exposure length of metering scale at full, 3/4th

and half hopper filling capacity. The available rotor numbers 12 were used for the study. Total three replications were taken for calibration of planter. There was no remarkable variation of seed rate for three replications.

4.3.1 Selection of metering rotor for cowpea

Preliminary tests were conducted to select most suitable metering rotor size before the experiment. As per the observed values of seed size and cup size of metering rotor no. 12 (4 grooves with distance 20 cm) was selected for calibration and sowing of developed planter for cowpea. To maintain 30 x 40 cm row to row and plant to plant distance for cowpea two grooves were kept closed. Table shows the calibration results of cowpea seed with different metering exposure scale (6, 5, and 4) and with metering rotor 12. Data table shown Appendix A.

4.3.2 Theoretical seeding rate (R_{st})

The theoretical seeding rate for cowpea was calculated 83334 seed per hectare. The row width was 30 cm and seed to seed spacing was 40 cm.

The capacity of seed hopper box was found to be 3.85 kg for cowpea crop. So, planter can drop 37540 seeds in one time hopper filling up to full capacity and it requires 2 full filled and one $1/4^{th}$ filled hopper to cover total one hectare area.

4.3.3 Seeding mass rate (R_{sm})

Seeding mass rate was calculated for cowpea was 0.0154 Mg ha^{-1}. The average mass of one seed is determined by average weight of 100 manually counted cowpea seeds. The row width was taken 30 cm and seed spacing in row was 40 cm. Data revealed that with metering rotor no. 12 and scale exposure of 5 gave the nearest values of seeding mass rate 15.40 kg/ha which is in the range of 15- 20 kg/ha. From calculation 8.35 gram seed should be discharged with in 20 revolutions of wheels.

Table 4.2 Average weight of seed collected of cowpea at furrow opener

Hopper capacity	Scale exposure no.		
	6	5	4
Half	7.81	8.17	9.09
3/4th	8.27	8.58	9.73
Full	10.3	11.34	12.4

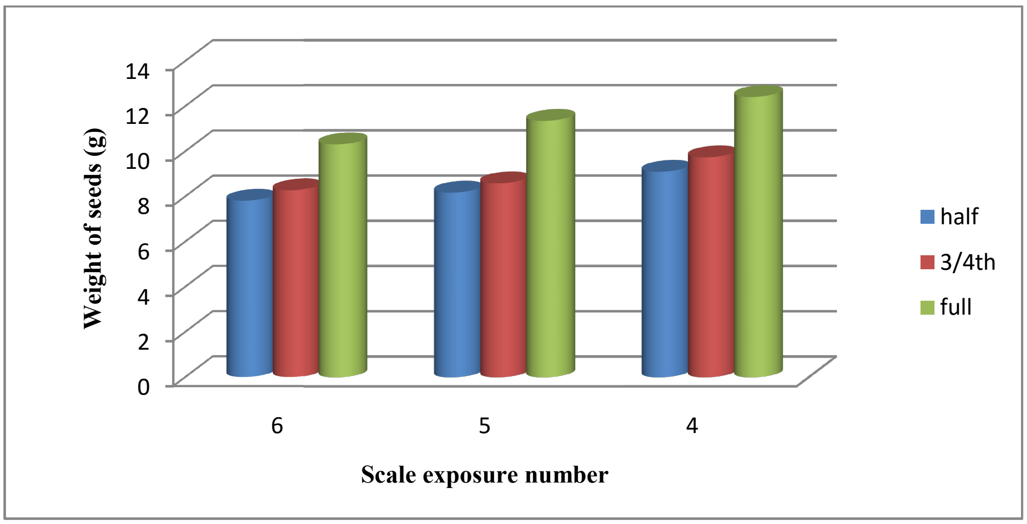


Fig. 4.1 Comparison if different capacities of hopper on the amount of seed drop after 20 revolutions with different exposure scale for cowpea

4.3.4 Seed damage determination test

Seed damage determination test was used to determine mechanical damage if any done to the seeds during calibration. Seed sample from the seed hopper as well as from the seeds passing through the metering device are collected and analyzed then taken in two slots viz., undamaged seeds and damaged seed separately. Visual observations for mechanical damage due to metering mechanism were recorded and the results are shown in Table below. It was found that no any mechanical damage of seed observed in cowpea.

Table 4.3 Test results of seed damage determination test

Crop	obs. No.	Total weight of seed (g)	Weight of damaged seed (g)	Seed damage (%)
Cowpea	1	17	0	0
	2	18.5	0	0
	3	19	0	0
	Avg.	18.16	0	0

4.3.5 Field tests

The developed double row manual operated vegetable seed planter was tested for its mechanical and functional performances in the field area of department of precision farming and development center, college of agriculture, IGKV, Raipur. The plot size of 10m x 2m is plotted for each crop and three replications of cowpea crop were taken in Randomized block design.

4.3.5.1 Depth of seed placement

The average depth was observed to be 4.08 cm for cowpea. Five random observations was taken and average depth of seed placement for different crops. The values of observations are shown below in Table 4.9. Depth could be easily adjusted by furrow opener having depth adjustment by moving vertically up or down in the holder and fixing it with the bolt.

4.3.5.2 Seed to seed spacing

The average seed to seed spacing was found to be 40.4 for cowpea. The spacing between seeds was all nearby the recommended seed distance. The observed values are shown in the Table 4.9.

4.3.5.3 Row to row distance

The row to row distance was fixed to 30 cm. The average distance was taken. Variation in the fixed row to row distance was due to draft and vibration of the machine during operation. The average distance was found 30 cm for cowpea.

Table 4.4 Placement data sheet for cowpea

Parameters	Measuring points					Average
	1	2	3	4	5	
Depth of seed, cm	4.2	4.3	3.8	3.9	4.2	4.08
Seed to seed spacing, cm	40	41	40	40	41	40.4
Row to row spacing, cm	30	30	30	30	30	30

4.3.6 Miss Index (MI) and Multiple Index

Miss Index for cowpea was found 3% and Multiple Index found 2% for cowpea. The recorded data table showed Appendix D-1.

4.3.7 Coefficient of variance

Coefficient of variance for cowpea along the line segment of 40 m was found 0.18. The CV of the machine was found low. So, it can conclude that the machine gives good performance.

4.3.4 Actual average travelling speed

The actual average travelling speed of sowing operation with developed seed planter was found 1.1 km/h. It was found that the operating speed varied from 1 to 1.4 km/h. and recommended travelling speed for manual drawn machine is 1.2 km/h.

4.3.5 Theoretical field capacity

Theoretical field capacity of the double row vegetable seed planter is the area covered per hour theoretically. The width of the planter is 0.6 m and speed 1.2 km/h. The TFC was found for cowpea was 0.072 ha/h.

4.3.6 Actual field capacity

Effective field capacity is the actual area covered. EFC was calculated separately for each crop and found to be 0.051 ha/h for cowpea.

4.3.7 Field efficiency

Field efficiency is the ratio of EFC and TFC expressed in percentage. The field efficiency for cowpea was found 70.8 %.

4.3.8 Plant population

The average plant population per hectare was recorded 37500 for cowpea. Plant population of depends upon row to row and plant to plant distance of crop.

Table 4.5 Performance parameters of field tests

Parameters	**Results**
Theoretical field capacity, ha/h	0.072
Actual Field capacity, ha/h	0.051
Field Efficiency, %	70.8
Seeding mass rate, kg/ha	15.4
Plant Population, number	37500

4.4 Testing of Double Row Vegetable Seed Planter for Okra Crop

4.4.1 Selection of metering rotor for okra

On the basis of preliminary test results, metering rotor no. 12 was selected for calibration and sowing of okra seeds by developed vegetable seed planter.

4.4.1 Theoretical seeding rate (R_{st})

The theoretical seeding rate for okra was also calculated 83334 seed per hectare. The row width was fixed 30 cm and seed to seed spacing was 40 cm.

The capacity of seed hopper box was found to be 2.94 kg for cowpea crop and it carries 51190 seed in full filled hopper. So, planter can drop 51190 seeds in one time hopper filling up to full capacity and it requires one full filled and one half filled hoppers to cover total one hectare area.

4.4.2 Seeding mass rate (R_{sm})

Seeding mass rate was calculated for okra was 0.0149 Mg ha^{-1}. The average weight of one seed for okra was minimum so seeding mass rate found minimum. Recommend seed rate for okra is 12-14 kg/ha. The observed values of seed rate for different metering exposure scale shown in the table below. Table revealed that nearest recommended seeding mass rate of okra seed was obtained 14.97 kg/ha with exposure scale no. 6. From calculation 7.8 gram seed should be discharged with in 20 revolutions of wheels.

Table 4.6 Average weight of seed collected of okra at furrow opener

Hopper capacity	**Scale exposure no.**		
	6	5	4
Half	6.76	6.94	7.29
$3/4^{th}$	7.41	7.85	8.12
Full	8.34	8.98	9.63

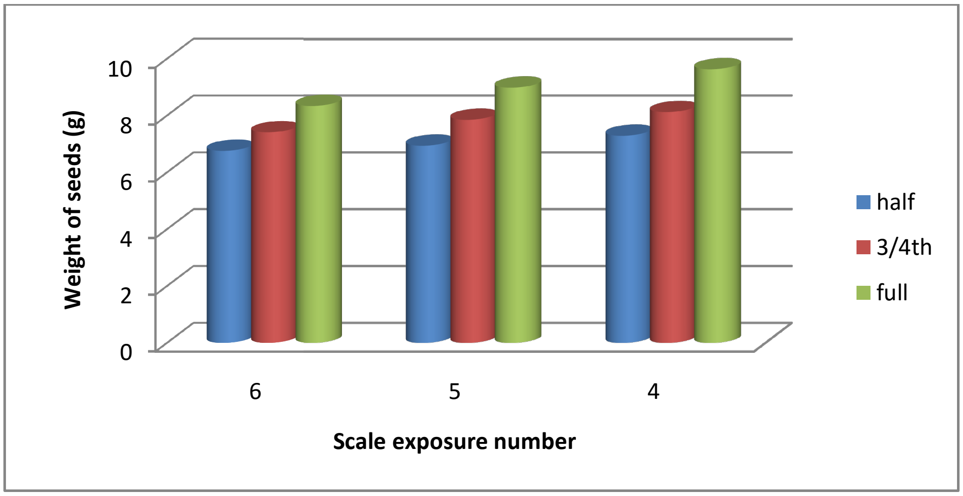


Fig. 4.2 Comparison of different capacities of hopper on the amount of seed drop after 20 revolutions with different exposure scale for okra

4.4.2 Seed damage determination tests

The seed damage determination tests were conducted same as for cowpea seed. No any mechanical damage found during calibration in okra crop.

Table 4.7 Test results for seed damage for okra

Crop	Obs. No.	Total weight of seed (g)	Weight of damaged seed (g)	Seed damage (%)
Okra	1	22	0	0
	2	23	0	0
	3	22	0	0
	Avg.	22.34	0	0

4.4.3 Placement data sheet for Okra

Depth of seed found in okra crop 4.28 cm, seed to seed spacing 40.26 cm and row to row distance 30.04cm.

Table 4.8 Placement data sheet for okra

Parameters	Measuring points					Average(cm)
	1	2	3	4	5	
Depth of seed, cm	4.3	4.4	4.3	4.2	4.2	4.28
Seed to seed spacing, cm	40.4	40.3	40	40.2	40.4	40.26
Row to row spacing, cm	30	30	30	30.2	30	30.04

4.4.4 Performance results of field tests

The TFC for okra crop was calculated 0.072 ha/h, EFC was found 0.050 ha/h, field efficiency was found 69.4%, seed rate of okra crop is 14.97 kg/ha. Plant population was found 42000 plants per hectare.

Table 4.9 Performance parameters of field tests

Parameters	Results
Theoretical field capacity, ha/h	0.072
Actual Field capacity, ha/h	0.050
Field Efficiency, %	69.4
Seeding mass Rate, kg/ha	14.97
Plant Population, number	42000

4.4.5 Miss and Multiple Index

Miss index for okra crop was found 4% and Multiple Index found to be 3%.

4.4.6 Coefficient of variance

Coefficient of variance found for okra crop was 0.25. It is the ratio between standard deviation to mean.

4.4 Testing of Double Row Vegetable Seed Planter for Pea Crop

4.5.1 Selection of rotor for Pea crop

Metering rotor no. 12 (4 grooves with 20 cm distance) was selected for calibration and sowing of pea of developed vegetable planer.

4.3.4 Theoretical seeding rate (R_{st})

The theoretical seeding rate for pea was calculated 166667 seed per hectare. The row width was 30 cm and seed to seed spacing was 20 cm.

The capacity of seed hopper box was found to be 4.1 kg for cowpea crop and it carries 20476 seed in full filled hopper. So, planter can drop 20476 seeds in one time hopper filling up to full capacity and it requires 8 full filled hopper to cover total one hectare area.

4.3.5 Seeding mass rate (R_{sm})

Seeding mass rate was calculated for pea was 0.1524 Mg ha^{-1}. Recommended seed rate of pea is 150 kg/ha. The observed values of seed rate for different metering exposure scale shown in the table below. Table revealed that nearest recommended seeding mass rate of pea seed was obtained 152.80 kg/ha with exposure scale no. 5. From calculation 41.76 gram seed should be discharged with in 20 revolutions of wheels.

Table 4.10 Average weight of seed collected of Pea at furrow opener

Hopper capacity	**Scale exposure no.**		
	6	5	4
Half	38.56	39.34	41.20
$3/4^{th}$	40.17	40.90	41.61
Full	41.66	42.48	43.03

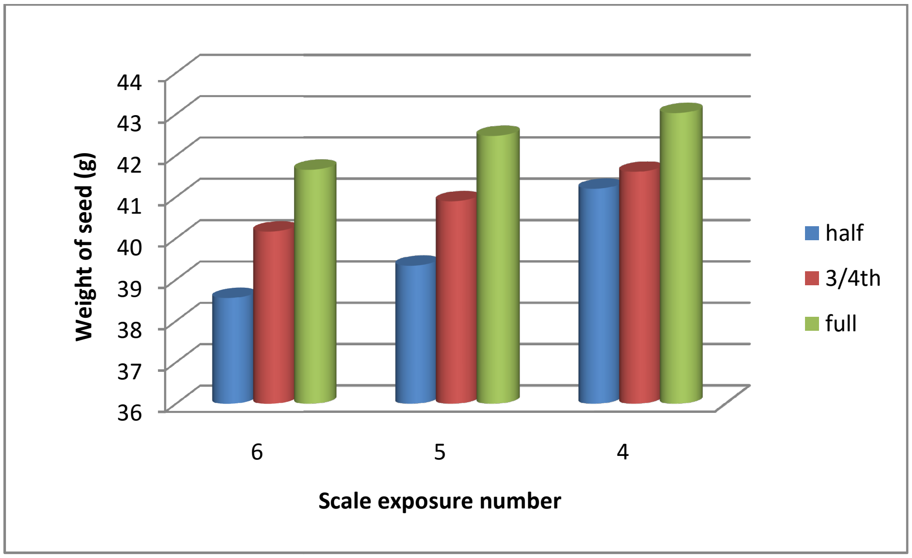


Fig. 4.3 Comparison of different capacities of hopper on the amount of seed drop after 20 rev. with different exposure scale for pea

4.5.2 Seed damage determination tests

No any mechanical damage found during calibration in pea crop.

Table 4.11 Test results of seed damage for pea crop

Crop	Obs. No.	Total weight of seed (g)	Weight of damaged seed (g)	Seed damage (%)
Pea	1	20	0	0
	2	18	0	0
	3	18	0	0

4.5.3 Placement data sheet for Pea

Depth of seed found in Pea crop was 4.08 cm, seed to seed spacing 20.58 cm, row to row distance 30.22 cm.

Table 4.12 Placement data sheet for Pea crop

Parameters	Measuring points					Average
	1	2	3	4	5	
Depth of seed, cm	4.2	3.9	3.8	4.2	4.3	4.08
Seed to seed spacing, cm	20	20.4	20.5	21	21	20.58
Row to row spacing, cm	30.2	30	30.5	30.4	30	30.22

4.5.4 Performance results of field tests

The TFC was calculated 0.072 ha/h, EFC was found 0.052 ha/h, field efficiency was found 72.2 %, seed rate of pea crop is 152.4 kg/ha. Plant population for pea crop was found 250000 plants per hectare.

Table 4.13 Performance parameters of field tests

Parameters	Results
Theoretical field capacity, ha/h	0.072
Actual Field capacity, ha/h	0.052
Field Efficiency, %	72.2
Seeding mass Rate, kg/ha	152.4
Plant Population, number	250000

The field efficiency was found maximum for pea crop because of time taken for sowing of pea crop is less as compared to other crop.

Plant population was also found maximum for pea crop because plant to plant distance was less as compared to other crops.

4.3.6 Miss and Multiple Index

Miss index for pea crop was found 2% and Multiple Index found 2%.

4.3.7 Coefficient of variance

Coefficient of variance (CV) for pea crop along with the line segment of 40 m was calculated by ratio of standard deviation and mean and it was found 0.17.

4.5 Testing of Double Row Vegetable Seed Planter for Dolichos Bean

4.5.1 Selection of rotor for dolichos bean

Metering rotor no. 12 with closed two grooves was selected for calibration and sowing of dolichos bean (30 x 40) of developed vegetable planer.

4.5.2 Theoretical seeding rate (R_{st})

The theoretical seeding rate for dolichos bean was also calculated 83334 seed per hectare. The row width was fixed 30 cm and seed to seed spacing was 40 cm.

The capacity of seed hopper box was found to be 3.94 kg for dolichos bean crop and it carries 15870 seed in full filled hopper. So, planter can drop 15870 seeds in one time hopper filling up to full capacity and it requires five full filled and $1/4^{th}$ filled hoppers to cover total one hectare area.

4.5.3 Seeding mass rate (R_{sm})

Seeding mass rate was calculated for dolichos bean was 0.0312 Mg ha-1. The average weight of one seed for okra was minimum so seeding mass rate found minimum. Recommend seed rate for okra is 30-40 kg/ha. The observed values of seed rate for different metering exposure scale shown in the table below. Table revealed that nearest recommended seed rate of dolichos bean seed was obtained 31.21 kg/ha with exposure scale no. 5. From calculation 16.74 gram seed should be discharged with in 20 revolutions of wheels.

Table 4.14 Average weight of seed collected of dolichos bean at furrow opener

Hopper capacity	Scale exposure no.		
	6	5	4
Half	16	16.57	16.81
3/4th	16.73	17.38	17.59
Full	17.44	17.85	18.25

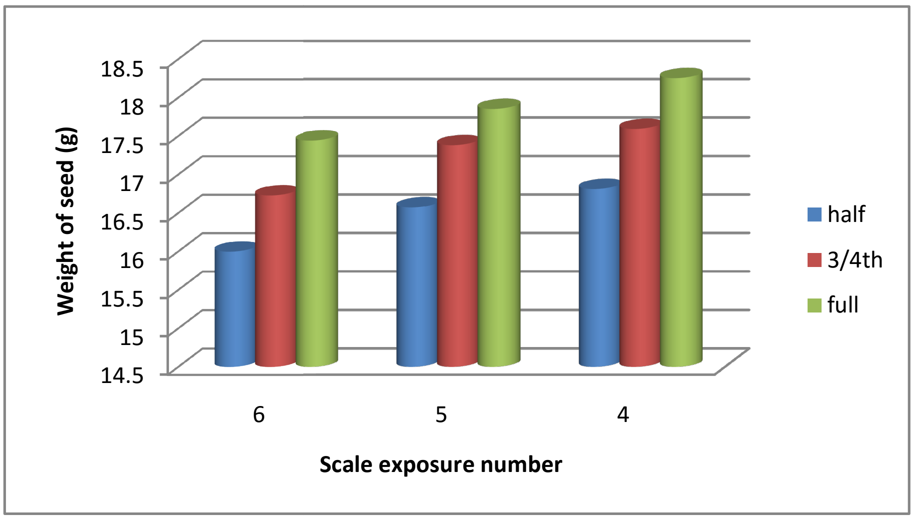


Fig. 4.4 Comparision of different capacities of hopper on the amount of seed drop after 20 revolution with different exposure scale for dolichos bean

4.5.4 Seed damage determination tests

Average mechanical damage found during calibration in 0.29% in dolichos bean crop.

Table 4.15 Test result of seed damage for different crops

Crop	Obs. No.	Total weight of seed (g)	Weight of damaged seed (g)	Seed damage (%)
Dolichos bean	1	24	0	0
	2	23	0.2	0.87
	3	22	0	0
	Avg.	23	0.06	0.29

4.5.5 Placement data sheet for dolichos bean

Depth of seed in dolichos bean was found 4.2 cm, seed to seed spacing 40.54 cm, and row to row spacing 30.16 cm.

Table 4.16 Placement data sheet for dolichos bean

Parameters	Measuring points					Average
	1	2	3	4	5	
Depth of seed, cm	3.9	4.3	4.3	4.3	4.2	4.2
Seed to seed spacing, cm	40	41	41.4	40.3	40	40.54
Row to row spacing, cm	30	30.4	30	30	30.4	30.16

4.5.6 Performance results of field tests

The TFC was calculated 0.072 ha/h, EFC was found 0.049 ha/h, field efficiency was found 68%. Seed rate of dolichos bean is 31.21 kg/ha. Plant population per hectare for dolichos bean was found 250000.

Table 4.17 Performance parameters of field tests

Parameters	Results
Theoretical field capacity, ha/h	0.072
Actual Field capacity, ha/h	0.049
Field Efficiency, %	68
Seed Rate, kg/ha	31.21
Plant Population, number	40300

4.5.7 Miss and Multiple Index

Miss index for pea crop was found 3% and Multiple Index found 2%. Data sheet shown Appendix D-2.

4.5.8 Coefficient of variance

Coefficient of Variance for dolichos bean was calculated by ratio of standard deviation and mean and it was found 0.20.

4.4 Cost Analysis of Developed Vegetable Planter

Total Cost of developed double row manual operated vegetable seed planter was 17150 Rs. Cost analysis was done by straight line method. It is the sum of total fixed cost and total variable cost. Cost of sowing for each crop was calculated. It was found that cost of sowing for cowpea was 1039.2 Rs/ha, for okra 1060 Rs/ha, for pea 1019.2 Rs/ha and for bean 1081.6 Rs/ha.

CHAPTER- V

SUMMARY AND CONCLUSIONS

Sowing is the technique of planting seeds. The key guideline of sowing task is to put the seed ad manure in columns at required profundity and dispersing, cover the seeds with soil and give legitimate compaction over the seed.

The north and south platue of Chhattisgarh region adopt indigenous methods for sowing operation of vegetables i.e. broadcasting, line sowing etc. Seed drill for vegetable crop in not available in Chhattisgarh. Most of the farmers cultivate Badi by raising vegetables only. But not any suitable sowing machine has available for farmers. Previously single row manual operated vegetable planter has developed but the capacity of that machine is low. So the objectives of the research work will fulfil the need of the farmers with high capacity, more efficiency and low cost. Objectives of the research work are:

1. To develop double row manually operated vegetable planter for suitable vegetable seeds.
2. To test and evaluate the performance of the developed planter.
3. To workout operational cost of planting.

FINDINGS:

The developed manual operated double row vegetable seed planter was tested for its performance in laboratory and in field. Based on the experiment conducted following results were obtained:

1. Theoretical seeding rate (Rst) for cowpea, okra and dolichos bean was calculated 83334 seed per hectare and for pea it was calculated 166667 seed per hectare.
2. Seeding mass rate of manual operated vegetable planter for selected crops with selected metering rotor in laboratory:
   1. For cowpea crop metering disc no. 12 and scale exposure of 5 gave nearest values of seed rate 15.40 kg/ha which is in the range of 15-20

kg/ha. From calculation 8.35 gm seed should be discharged with in 20 revolutions of wheels.

2. For okra crop metering disc no. 12 and scale exposure of 6 gave nearest values of seed rate 14.97 kg/ha which is in the range of 12-14 kg/ha. From calculation 7.8 gm seed should be discharged with in 20 revolutions of wheels.
3. For pea crop metering disc no. 12 and scale exposure of 6 gave nearest values of seed rate 152.80 kg/ha which is in the range of 150 kg/ha. From calculation 42 gm seed should be discharged with in 20 revolutions of wheels.
4. For dolichos bean crop metering disc no. 12 and scale exposure of 5 gave nearest values of seed rate 31.21 kg/ha which is in the range of 30-40 kg/ha. From calculation 16 gm seed should be discharged with in 20 revolutions of wheels.

3. It was found that the no any seed damage occurred during calibration for cowpea, okra, pea and 0.29% of seed damage found for dolichus bean.
4. The average moisture content of the soil was measured from five random samples from different location of the field was found to be 5.16 % in dry basis.
5. The bulk density of the test plot soil was found 1.38 $gm/cm^{3.}$
6. The average depth of placement of seeds was observed to be 4.08 cm for cowpea, 4.28 cm for okra, 4.08 cm for pea and 4.2 cm for dolichos bean.
7. The average seed to seed distance was found 40.4 cm for cowpea, 40.26 cm for okra, 20.58 cm for pea and 40.54 cm for dolichos bean.
8. The Miss Index was found 3% for cowpea, 4% for okra, 2% for pea and 3% for dolichos bean.
9. The Multiple Index was found 2% for cowpea, 3% for okra, 2% for pea and 2% for dolichos bean.
10. The coefficient of variance was calculated and found to be 0.18 for cowpea, 0.25 for okra, 0.17 for pea and 0.20 for dolichos bean.
11. The theoretical field capacity was found to be 0.072 ha/h for all four crops.

12. The actual average travelling speed of operation of the developed vegetable seed planter was found 1.2 km/h.
13. It was found that actual field capacity for cowpea, okra, pea and dolichus bean were 0.051, 0.050, 0.052, 0.049 ha/h respectively.
14. Field efficiency was found 70.8 % for cowpea, 69.4% for okra, 72.2 % for pea and 68% for dolichos bean.
15. The average plant population per hectare was recorded 37500 for cowpea, 42000 for okra, 40300 for dolichos bean and 250000 for pea crop.
16. The cost of developed vegetable seed planter was found 17150 Rs. It was found that cost of sowing for cowpea was 1039.2 Rs/ha, for okra 1060 Rs/ha, for pea 1019.2 Rs/ha and for bean 1081.6 Rs/ha.

CONCLUSIONS:

As per the objectives of the present study and results obtained, following conclusion could be drawn:

1. As per the design consideration the developed planter was rigid, reliable and light in weight.
2. The performance of the vegetable seed planter was satisfactorily in laboratory as well as in the actual field condition for all selected crops.
3. The cost of planting operation was also not so high. The cost of developed vegetable seed planter was found 17150 Rs. It was found that cost of sowing for cowpea was 1039.2 Rs/ha, for okra 1060 Rs/ha, for pea 1019.2 Rs/ha and for bean 1081.6 Rs/ha.

SUGGESTIONS FOR FUTURE RESEARCH WORK

1. Developed vegetable planter may be tested for other crops of small seed size.
2. Ergonomic evaluation of the developed vegetable planter could be carried out to provide more comfort to the operator such as pedal, seat etc.
3. The machine should be tested for the attachment of fertilizer box with the developed vegetable seed planter.

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APPENDIX-A

Table A-1 Moisture content of soil

Obs.	Sample weight (g)	Weight of container (g)	Weight of container + sample	Weight of container + dried soil	Mc in db (%)
1	187.9	26.3	214.2	208.1	3.35
2	188.4	26.4	214.8	206.3	4.72
3	189.3	26.6	215.9	207.4	4.70
4	187.8	26.3	214.1	204.6	5.34
5	190.2	27.0	217.2	203.6	7.70
Avg.					5.16

Table A-2 Bulk density of soil

Observation	Weight of soil in core cutter (gm)	Weight of dried soil (gm) (M)	Volume of core cutter(cm^3)(V)	Bulk density (Kg/m^3) (M/V)
1	1552.0	1447.2	1021	1.41
2	1526.2	1433.4	1021	1.40
3	1518.0	1420.0	1021	1.39
4	1502.0	1413.0	1021	1.38
5	1500.0	1404.2	1021	1.37
			Average	1.39

Calculation of amount of seed dropped in 20 revolution of ground wheel

a) For cowpea crop

Effective width of planter = 2 x 30 cm = 60 cm = 0.6 m

Circumference of ground wheel = 116 cm = 1.16 m

Distance covered in 20 revolution of ground wheel = 20 x 1.16 x 0.6 m = 13.92 m

Seed to seed distance of cowpea = 40 cm = 0.4 m

Area covered in 20 revolutions = 13.92 x 0.40 = 5.568 m^2

Seed rate of cowpea is 15-20 kg/ha

For 10000 m^2, 15000 gm seed required

Therefore for 5.568 m^2

$$= \frac{15000}{10000} \times 5.568$$

$$= 8.35 \text{ g}$$

Table A-3 Calibration of planter for cowpea at full hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	**Metering rotor**			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	10.2	10.4	10.3	10.30
5	11.5	11.3	11.3	11.38
4	12.3	12.3	12.5	12.40

Table A-4 Calibration of planter for cowpea at 3/4th hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	8.2	8.1	8.4	8.27
5	8.3	8.9	8.5	8.58
4	9.7	9.8	9.6	9.73

Table A-5 Calibration of planter for cowpea at half hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	7.7	7.7	7.9	7.81
5	8.4	8.0	8.0	8.17
4	8.9	9.2	9.1	9.09

b) For okra crop

Effective width of planter = 2 x 30 cm = 60 cm = 0.6 m

Circumference of ground wheel = 116 cm = 1.16 m

Distance covered in 20 revolution of ground wheel = 20 x 1.16 x 0.6 m

= 13.92 m

Seed to seed distance of cowpea = 40 cm = 0.4 m

Area covered in 20 revolutions = 13.92 x 0.40 = 5.568 m^2

Seed rate of cowpea is 14 kg/ha

For 10000 m^2, 14000 gm seed required

Therefore for 5.568 m^2

$$= \frac{14000}{10000} \times 5.568$$

$$= 7.79 \text{ g}$$

Table A-6 Calibration of planter for okra at full hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	8.2	8.4	8.3	8.34
5	9.2	8.8	8.9	8.98
4	9.7	9.6	9.6	9.63

Table A-7 Calibration of planter for okra at 3/4th hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	7.4	7.4	7.3	7.41
5	7.7	7.9	7.8	7.85
4	8.1	8.1	8.0	8.12

Table A-8 Calibration of planter for okra at half hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	**Metering rotor**			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	6.7	6.7	6.8	6.76
5	7.0	6.9	6.9	6.94
4	7.3	7.3	7.2	7.29

c) For pea crop

Effective width of planter = 2 x 30cm =60 cm= 0.6 m

Circumference of ground wheel = 116 cm = 1.16 m

Distance covered in 20 revolution of ground wheel = 20 x 1.16 x 0.6 m = 13.92 m

Seed to seed distance of cowpea = 20 cm = 0.2 m

Area covered in 20 revolutions = 13.92 x 0.20 = 2.784 m^2

Seed rate of cowpea is 150 kg/ha

For 10000 m^2, 150000 gm seed required

Therefore for 2.784 m^2

$$= \frac{150000}{10000} \times 2.784$$

= 41.76 g

Table A-9 Calibration of planter for pea at full hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	41.8	41.6	41.6	41.66
5	42.3	42.4	42.7	42.48
4	43.2	43.0	42.9	43.03

Table A-10 Calibration of planter for pea at 3/4th hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	40.2	40.2	40.1	40.17
5	40.6	41.3	40.8	40.90
4	41.8	41.4	41.6	41.61

Table A-11 Calibration of planter for pea at half hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	38.4	38.6	38.7	38.56
5	39.5	39.2	39.3	39.34
4	40.8	41.3	41.5	41.20

d) For dolichos bean

Effective width of planter = 2 x 30 cm = 60 cm = 0.6 m

Circumference of ground wheel = 116 cm = 1.16 m

Distance covered in 20 revolution of ground wheel = 20 x 1.16 x 0.6 m

= 13.92 m

Seed to seed distance of cowpea = 40 cm = 0.4 m

Area covered in 20 revolutions = 13.92 x 0.40 = 5.568 m^2

Seed rate of cowpea is 30-40 kg/ha

For 10000 m^2, 30000 gm seed required

Therefore for 5.568 m^2

$$= \frac{30000}{10000} \times 5.568$$

= 16.704 g

Table A-12 Calibration of planter for dolichos bean at full hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	**Metering rotor**			
	Weight of seed collected at furrow opener (g)			
	R1	R2	R3	Average
6	17.5	17.4	17.4	17.44
5	17.8	17.7	17.9	17.85
4	18.1	18.2	18.3	18.25

Table A-13 Calibration of planter for dolichos bean at 3/4th hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(g)			
	R1	R2	R3	Average
6	16.7	16.8	16.7	16.73
5	17.4	17.3	17.3	17.38
4	17.6	17.5	17.5	17.59

Table A-14 Calibration of planter for dolichos bean at half hopper level by giving 20 revolutions to the ground wheel

Scale exposure no.	Metering rotor			
	Weight of seed collected at furrow opener(gm)			
	R1	R2	R3	Average
6	15.9	15.9	16.0	15.99
5	16.6	16.5	16.5	16.57
4	16.9	16.8	16.7	16.81

APPENDIX – B

Calculation of theoretical field capacity, effective field capacity and field efficiency of selected crops

Theoretical field capacity

The theoretical field capacity was calculated by following formula:

Theoretical field capacity (ha/h) = $\frac{\text{width (m)x speed (kmph)}}{10}$ x 100

$= \frac{0.6\ x\ 1.2}{10}$ x 100

= 0.072 ha

Actual field capacity (EFC):

It was calculated by following formula:

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

a) For cowpea crop

Area = 0.1 ha

Time required = 1.96 h

$= \frac{0.1}{1.96}$

= 0.051 ha/h

b) For okra crop

Area = 0.1 ha

Time required = 1.99 h

$= \frac{0.1}{1.99}$

= 0.050 ha/h

c) For pea crop

Area = 0.1 ha

Time required = 1.92 h

$= \frac{0.1}{1.92}$ = 0.052 ha/h

d) For dolichus bean crop

Area = 0.1 ha

Time required = 2.02 h

$= \frac{0.1}{2.02}$ = 0.049 ha/h

Field efficiency

Field efficiency was calculated by following formula:

Field efficiency = $\frac{\text{Effective field capacity (ha/h)}}{\text{Theoretical field capacity (ha/h)}}$ x 100

a) For cowpea crop

$= \frac{0.051}{0.072}$ = 70.8%

b) For okra crop

$= \frac{0.050}{0.072}$ = 69.4%

c) For pea crop

$= \frac{0.052}{0.072}$ = 72.2%

d) For dolichos bean

$= \frac{0.049}{0.072}$ = 68%

APPENDIX- C

Cost analysis of developed manual operated double row vegetable seed planter and cost of sowing per hectare

1. **Fabrication cost**

Total weight of implement was 40 kg.

a) Material cost

Material cost was calculated 13100 Rs.

Table C-1:- Different Components and their cost of developed machine

S. No.	Part	Material	Quantity	Price, (Rs)
1	Frame	MS angle	-	1500
2	single box Hopper with seed box	plastic box	2	2000
3	single seed box shaft	M S angle	2	400
4	7/8 no. Rotor 4 groove	Plastic	4	200
5	furrow opener	M.S. Flat	2	800
6	chain and sprocket	stainless steel	1	300
7	Sprocket wheel 18 teeth	Stainless steel	2	80
8	Ground wheel		1	800
9	Support wheel		2	1800
10	Colour		1	250
11	Miscellaneous			4970
	Total			13100

b) Machine charge

It includes the welding, grinder and drilling machine charges @ Rs. 200/day.

$= 5 \times 200$

$= 1000$ Rs.

c) Blacksmith charge

It was taken as @ 300/day.

= 300 × 5

= 1500 Rs.

d) Supervision charges

It was taken as 10 % of (a + b + c).

= 10% of (13100+1000 + 1500)

= 1560 Rs.

Total fabrication cost = a + b + c +d

= 13100 + 1000 + 1500+1560

= 17160 Rs. ≈ 17150 Rs.

2. **Analysis of economic use of developed implement.**

Assumptions,

a. Expected life of machine = 10 year

b. Annual use of machine = 30 days

c. Salvage value of the planter = 10 % of initial cost.

3. **Fixed cost of the developed implement**

a) Depreciation

$D = \frac{C-S}{LXH}$

Where, D = Depreciation per hour

C = Purchase price, Rs = 17150

S = Salvage value, Rs. (Which is 10% of purchase price)

L = Life of machine, year

H = no of operating hours per year

D = $\frac{17150-1715}{10 \text{ x } 240}$

= 6.431 Rs/h

b) Interest on Investment

Interest (Rs/h) = $\frac{C+S}{2}$ x $\frac{i}{H}$

Where, i = % rate of interest per year = 12 % per year

i = $\frac{17150+171}{2}$ x $\frac{0.12}{240}$

= 4.71 Rs/h

Total fixed cost = Depreciation + Interest

= 6.431 + 4.71

= 11.147 Rs/h

a) Repair and maintenance

The repair and maintenance cost is taken 6% of initial purchase price.

Repair and maintenance cost (Rs/h) = $\frac{C \text{ x } m}{H}$

m = repair and maintenance rate 6% of initial cost

= $\frac{17150 \text{ x } 0.06}{240}$ = 4.28 Rs/h

b) Labour charge

Labour charges = 300 Rs/day

For 8 h = 37.5 Rs/h

Total variable cost = 4.28 +37.5 = 41.787 Rs/h

Cost of sowing using the developed vegetable seed planter

Total cost of sowing per hour = Fixed cost + variable cost

= 11.14 + 41.78

= 52.93 ≈ 53Rs/h

Cost of sowing per hectare can be calculated as:

Sowing cost = $\frac{\text{Total cost (Rs/h)}}{\text{Effective field capacity (ha/h)}}$

a) For cowpea

= 53/ 0.051 = 1039.2 Rs/ha

b) For okra

= 53 / 0.050 = 1060 Rs/ha

c) For pea

= 53/ 0.052 = 1019.2 Rs/ha

d) For dolichos bean

= 53/ 0.049 = 1081.6 Rs/ha.

Appendix D

Table D-1: - Seed to seed spacing of crops

S. no.	Cowpea	Okra	Pea	Dolichos bean
1	40	42	20	42
2	40.5	45	20.3	45
3	42	40	20.2	36
4	41	32	20.6	38
5	39	50	21	24
6	39	62	19.2	18
7	41	61	19.8	38
8	44	49	20.6	38.9
9	43	19	20.8	38.4
10	42	18	23	35.4
11	44	24	18	34.5
12	36	26	18.3	40
13	38	28	18.5	43.2
14	41	32	19	40.8
15	39	33	20	42
16	41.7	40	18	41.3
17	42	42	18.4	42.1
18	42.9	40	19.3	40
19	44	42	22	42.3
20	43	45	23	41.4
21	41	48	22.4	45
22	43	52	23.1	44.3
23	44	54	22	42
24	39.8	55	24.1	38.9
25	40	42	22.7	39
26	42	48	25	37.8

S. no.	Cowpea	Okra	Pea	Dolichos bean
27	44	36	19	38.3
28	43	35	18	34.5
29	43.5	32	16	36
30	45	62	15.7	37
31	44	58	15	38.6
32	38	55	9.2	38.5
33	38.6	23	12	43
34	33	24	12.4	42
35	35	37	13	61
36	28	44	18	32.5
37	28.8	46	16.8	18
38	36	42	15	23
39	42	48	16.3	45
40	44.6	42	16.8	18
41	19	43	19	32
42	25	36	18.4	36
43	28	34	18.5	32.1
44	32	43	19.3	42
45	35	44	19.4	40.9
46	25	45	12	42.1
47	18	24	19.3	45
48	34	27	20	40
49	66	54	20.3	43
50	45	44	19	42
51	53	54	20.8	48
52	54	46	21	61
53	46	48	22	46
54	40	53	20	39

S. no.	Cowpea	Okra	Pea	Dolichos bean
55	42	35	25	41
56	41	34	18	44
57	42	31	24.5	39
58	43	37	24.5	39.5
59	58	39	20	41
60	55	40	25.3	42
61	53	40	19.8	44
62	48	41	32	44.5
63	42	48	27.3	44.6
64	45	40	24.3	42
65	34	39	20.8	45
66	38	38.5	22.3	46
67	43	52	20.1	46.5
68	41	42	22.1	45
69	40	44	20.4	44.3
70	53	46	20	42
71	42	45	20	36
72	43	36	20.1	35.5
73	52	38	20.4	34
74	42	39	20.4	35.5
75	43	40	20.6	35
76	44	41	20.9	36
77	28	28	21	38
78	32	32	21.9	39
79	38	44	19.8	55
80	33	31	30	54
81	37	27	24.2	52
82	40	37	22	48

S. no.	Cowpea	Okra	Pea	Dolichos bean
83	38	34	21.4	49
84	39	39	18	44
85	27.8	40	17.8	42
86	42	47	19.6	53
87	43	55	21	24
88	40	58	24.4	27
89	45	18	18.9	22
90	46	55	19	19
91	46.5	55.9	20	28
92	41	45	9.9	28.5
93	38	44	15	32.5
94	40	32	18	34.4
95	43	28	20	36.5
96	38	34	20	37.7
97	36	22	21	31
98	34.6	19	21.3	33
99	56	36	20.8	41
100	42	44	20.4	40
Mean	40.643	40.38	19.957	39.138
SD	7.396631	10.15	3.515227	8.051711
CV	0.18199	0.25	0.17614	0.205726
Total Miss	3	4	2	3
Total Multiple	2	3	2	2

Table D-2 Mean, Standard Deviation, Coefficient of Variance, Miss Index and Multiple Index.

S. no.	**Crop**	**Mean**	**SD**	**CV**	**Miss index**	**Multiple index**
1	Cowpea	40.64	7.39	0.18	3%	2%
2	Okra	40.38	10.15	0.25	4%	3%
3	Pea	19.95	3.51	0.17	2%	2%
4	Dolichos bean	39.13	8.05	0.20	3%	2%

RESUME

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