DEVELOPMENT OF TRACTOR OPERATED SEED FERTI DRILL-CUM-WEEDICIDE APPLICATOR

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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MASTER OF TECHNOLOGY
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(FARM POWER AND MACHINERY)

By

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Enrolment No. LL-2415 **2019**

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled "**DEVELOPMENT OF TRACTOR OPERATED SEED FERTI DRILL CUM-WEEDICIDE-APPLICATOR"** or part there has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or Scientific Organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Akola **(GHADGE AMOL SUKHDEO)**

Date: Enrollment No.: LL-2415

CERTIFICATE

This is to certify that thesis entitled **" DEVELOPMENT OF TRACTOR OPERATED SEED FERTI DRILL-CUM-WEEDICIDE APPLICATOR"** submitted in partial fulfillment of the requirement for the degree of **"Master of Technology in Agricultural Engineering" (Farm Power and Machinery)** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **GHADGE AMOL SUKHDEO** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA-VOCE)

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Abbreviations		Expanded Form
a	-	Area
Agril.	-	Agricultural
Agril. Engg.	-	Agricultural Engineering
ASABE	-	American Society of Agricultural and Biological Engineers
ASAE	-	American Society of Agricultural Engineering
Avg.	-	Average
BHP	-	Brake horse power
BM	-	Bending moment
CAET	-	College of Agricultural Engineering and Technology
cc	-	Cubic centimeter
CIAE	-	Central Institute of Agricultural Engineering
cm	-	Centimetre
D	-	Draft
Db	-	Dry basis
DBHP	-	Drawbar Horse Power
Deptt.	-	Department
CDF	-	Central Demonstration Farm
D_o	-	Basic Draft
Dr. PDKV	-	Dr. Panjabrao Deshmukh Krishi Vidyapeeth
E. F. C.	-	Effective field capacity
Engg.	-	Engineering
et al.	-	Et alibi (and others)
etc.	-	Etcetera
PTO	-	Power take off
fe	-	Field Efficiency
Fig.	-	Figure
FOS	-	Factor of safety
FPM	-	Farm Power and Machinery

G	-	Gram
g/cm^3	-	gram per cubic centimeter
h	-	Hour
ha	-	Hectare
ha/h	-	hectare per hour
hp	-	horse power
i.e.	-	that is
IS	-	Indian Standard
ISAE	-	Indian Society of Agricultural Engineering
J.	-	Journal
kg/cm^2	-	kilogram per centimeter square
kg/m^3	-	kilogram per meter cube
kg-f	-	kilogram force
km	-	Kilometer
km/h	-	kilometer per hour
kN	-	kilo Newton
kW	-	kilo watt
l	-	Liter
L	-	Length
l/h	-	liter per hour
l/ha	-	liter per hectare
M	-	Maximum bending moment
m	-	Metre
HTP	-	High Triplex power
M. Tech.	-	Master of Technology
m.s.	-	mild steel
mm/h	-	millimeter per hour
m/s	-	metre per second
m^2	-	metre square
m^3	-	meter cube
MC	-	Moisture Content
mm	-	Millimeter
N	-	Newton

No.	-	Number
P.N	-	Patent number
l/min	-	liter per minute
Rs	-	Rupees
Rs/h	-	Rupees per hour
Rs/ha	-	Rupees per hectare
S	-	Second
fb	-	bending stress
Sci.	-	Science
FOS	-	Factor of safety
SN	-	Serial Number
T. F. C	-	Theoretical field capacity
T_1	-	Non-productive time
T_p	-	Productive time
vol.	-	Volume
Vs	-	Versus
W	-	Width
wt.	-	weight
Z	-	Section modules
ρ	-	Bulk density
%	-	Per cent
@	-	At the rate

D) THESIS ABSTRACT

a)	**Title of the thesis**	:	**DEVELOPMENT OF TRACTOR OPERATED SEED FERTI DRILL-CUM-WEEDICIDE APPLICATOR**
b)	**Full name of student**	:	**Ghadge Amol Sukhdeo**
c)	**Name and address of Major Advisor**	:	**Dr. S. H. Thakare** Professor & Head, Deptt. of Farm Power and Machinery, Dr. PDKV, Akola.
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ABSTRACT

Farm mechanization is the application of engineering technology in agricultural operations to do a job in a better way to improve productivity. This includes development, application and management of all mechanical aids for field production, water control, material handling, storing and processing. Sustainable development in agriculture can be achieved by use of mechanization in agriculture. Mechanization can help in increasing the production by timely farm operations, reducing losses, reducing the cost of operations. It also ensures better management of costly inputs and enhances the productivity of natural resources. It also reduces drudgery in

farm operations. Mechanization of different farm operations can increase the agricultural productivity by more work in less time, efficient use of inputs, by producing quality product, improving the safety of the farmers, reducing the loss of produce and drudgery of farmers thus, improving comforts of farmers. It reduces the manpower as in today's scenario labours are difficult to find as well as it reduces the working time.

Tractor operated seed ferti drill-cum-weedicide applicator was developed and evaluated techno-economic feasibility in the field at Central Demonstration Farm, Wani-Rambhapur Dr. PDKV Akola. During sowing season of the crop, there is an acute shortage of labour, which causes delay in sowing of crop which ultimately results in a reduction of yield. Sowing or drilling the seed is one of the important operations for the crop. After sowing of the seed in field simultaneously weed also grow. Weeds are the most serious problem to the farmers which create obstruction for crop growth and compete with the crop. Application of the weedicide simultaneously along with sowing will minimize the problem and it will save complete operation of spraying weedicide.

Farmers fall in the category of marginal, small and semi-medium land holding. They could not offer all type of the implements for crop production. Therefore, an attempt was made to develop tractor operated seed ferti drill-cum-weedicide applicator to minimize weed infestation and simultaneously save the operation of weedicide application.

Techno-economic performance evaluation of tractor operated seed ferti drill-cum-weedicide applicator was carried out during the study. Chick pea was sowing with the use of seed ferti drill-cum weedicide applicator and Implement was tested in laboratory and in the field. Spacing between two adjacentent tynes were 450 mm. The working width was 2550 mm. The average draft requirement of the implement was 303.6 kgf for implement at an average speed of 3.25 km/h for the range of 45 hp tractor.

For weedicide spraying operation, fuel consumption and average tractor wheel slip were found 4.52 l/ha and 9.87 per cent, respectively. The effective field capacity, theoretical field capacity and field efficiency of implement was found to be 0.592 ha/h, 0.731 ha/h and 81.02 per cent respectively. Pendimethalin weedicide was sprayed simultaneously along with sowing of chick pea crop. 1000 ml weedicide was used for 200 lit tank for spraying on 0.60 ha. Average discharge rate of nozzle was 1.89 lit/min. cost of operation per hour and hectare of implement were Rs.645.53/- and Rs.1090.42/-. The overall performance of the tractor operated seed ferti drill cum weedicide applicator during the operation of weedicide spraying was found to be satisfactory.

CHAPTER I

INTRODUCTION

1.1 Background information

Farm mechanization is the application of engineering technology in agricultural operations to do the job in a better manner to improve productivity. This includes development, application and management of all mechanical aids for field production, water control, material handling, storing and processing. Sustainable development in agriculture can be achieved by mechanization in agriculture. Mechanization can help in increasing the production by timely farm operations, reducing losses, reducing the cost of operations. It also ensures better management of costly inputs and enhances the productivity of natural resources. It also reduces drudgery in farm operations. Mechanization of different farm operations can increase the agricultural productivity by increasing field capacity, efficient use of inputs, producing quality product, improving the safety of the farmers, reducing the loss of produce and drudgery of farmers thus, improving comforts of farmers. It helps to reduce the manpower as in today's scenario labours are very hard to find as well as it reduces the working time in field operation.

The agriculture sector is under increasing pressure to produce sustainable higher yields with less input, due to declining land and water productivity potential, increasing cost of production, variable market conditions and increasing world population. In recent years, it is imperative to improve sowing techniques through preferred seedbed preparation and early crop growth. Sowing techniques and type of seeding machines play an important role in seed placement and seedling emergence which ultimately affect crop growth and grain yield. The selection of suitable sowing methods is dependent upon the time of sowing, irrigation methods, amount of residue in the field and type of sowing machine.

The sowing operation is one of the most important cultural practices associated with crop production. Increase in crop yield, cropping reliability, cropping frequency and crop returns all depend on the uniform and timely establishment of seed into the field. There are two broad areas in optimizing seed establishment. First, seed growers and seed merchants have a responsibility to provide quality seeds. Second, farm managers must be aware of the agronomic requirements for optimum seed establishment and be able to interpret this information in a meaningful way so as to assist with the selection, setting and management of all farm machinery, especially seed drills.

Weed control is one of the serious problems faced by the farmers. Weed control in early stage of crop is the most important operation and delay in weed control may not compensate losses which the crops suffer in early growth stage.

In India, this operation is traditionally carried out with the indigenous hand tools. In single hand weeding, labour requirement is high as 300 to 1200 man-h/ha. Weeding is usually performed manually with traditional hand tools (*Khurpi*) in upright bending posture inducing back pain for majority of labourers and requires considerable time and labour.

Traditional methods of weeding and fertilizer application reduces the efficiency of work by increasing the requirement of labour cost. In traditional methods of weeding and fertilizer application animal drawn hoes made by village artisans from locally available material (usually wood for the framework and steel for the soil working components) are used widely by farmers. They require extra labour for fertilizer placement in the vicinity of crop root zone, two operations are carried separately.

Application of plant protection insecticides and pesticides through the equipment for controlling pests, diseases, insects and weeds plays an important role. As the chemicals are very costly, the uniform application and effective rate is the main requirement.

The main power source of the agriculture in Maharashtra is draft animals and majority of the small and marginal farmers depend on the draught animals for performing farm operations. Though, considerable mechanized and improved tractor drawn equipment's are available but due to lack of awareness and its use is limited. Day by day shortage of labour and increased wages of labour increasing cost of operation and has become great problem for small and marginal farmers. This leads to identification of mechanization gap, increase of annual hour's use of tractors in different farm operations by adopting improved implements.

The modern method of sowing is drilling with the help of seed drill. Seed drill is a device that deposits seeds in furrows and covers them with soil.

Weed is a major problem for the crop of growing. This create the obstruction to the crop during the growing hence its control is essential. If the intensity of weed is reduced the crop growth is good. There are two most important methods of control of weed by the chemicals. Pre-emergence and post emergence application of weedicide.

Pre-emergence application of the weedicide means application of weedicide before sowing of the crop. The pre-emergence weedicides are pendimethalin and s-metolachlor. It is an important operation of weedicide application to reduce the intensity of the weeds in field before the emergence of crop in the field. It is carried out at the stage when the moisture content in the field is available satisfactorily to the crop growth. Another method is post-emergence application of weedicide for reducing intensity of weed in the field. Post-emergence weedicide is glyphosate. It is also called Round up weedicide which is more useful for control the weeds and is applied after the crop emergence.

Presently farmers are using different types of implements for different farm operations as seed bed preparation, sowing, inter-culturing and spraying, etc. It is costly and difficult for small and marginal farmers to maintain number of implements. Therefore, considering above point it was decided to develop a tractor operated seed ferti drill-cum-weedicide applicator as combination tool to minimize number of implements, save number of operations, save time, labour and cost of production.

Tractor operated seed ferti-drill-cum-weedicide applicator was developed for carrying all operations simultaneously i.e. sowing, seed covering and application of fertilizers and weedicide at the time of sowing.

1.2 Necessity of Tractor Operated Seed Ferti Drill-Cum-Weedicide Applicator.

In India, diverse farm mechanization scenario prevails in the country due to varied size of the farm holdings and socio-economic disparities. In the trend of growth of power operated machinery used by farmers, Seed drill is used for sowing and drilling of the seed in field. Before the sowing of the seed into the field, farmer uses pre emergence application of weedicide solution in the field. Using manual sprayer, it is an important application which controls the weed into the field.

In India sowing is done by using of the tractor operated seed drills. After sowing, weedicide application is done manually but it requires more labour and time. Tractor operated seed ferti drill-cum-weedicide applicator helps in timeless operation and it does the sowing and weedicide application process at same time. The seed cum ferti drill were already developed and was available in market was selected and weedicide applicator was decided to develop.

Land holding is decreasing day by day so the requirement of efficient but less costly agricultural tool and equipment suitable for small farmers and small plots of land will continue to exist, whether owned or hired, there is urgent need of tractor operated equipment. Higher economic efficiency of scale of operation may compel farmers for co-operative/contract farming. High capacity, but precision equipment are needed for irrigated and dry land conditions Keeping the above point in view, the present investigation was undertaken with the following objectives.

1.3 Objectives of Study

1. To develop tractor operated seed ferti drill-cum-weedicide applicator.
2. To evaluate techno-economic performance of tractor operated seed ferti drill-cum-weedicide applicator.

1.4 Hypothesis

Development and performance evaluation of tractor operated seed ferti drill-cum-weedicide applicator can fulfill the intermediate mechanization gap between the sowing and weedicide spraying operation at the faster rate. Tractor operated seed ferti drill-cum-weedicide applicator may give the expected results. Therefore, there was an urgent need to introduce this type of implement. Development of tractor operated seed ferti drill-cum-weedicide applicator was the need of for today's farming to reduce the drudgery in the operation with saving time and labour and to do work effectively.

1.5 Scope and Limitations

Many of the farmers cannot afford different types of the implement used in the agricultural operations it is also like ploughing, harrowing, cultivator, weedicide sprayer etc. and it is also difficult to purchase for small and marginal farmers due to the high cost of the implement. Now a day's sowing operation done by the use of the draft animals in villages is also done by the use of tractor operated seed drills. Also sowing operation is done for the use of seed cum fertilizer drill. After some weeks of crop growth simultaneously weed is also grow in the field. For controlling the weed, weedicide application with the help manually operated sprayer on it for reducing the weed is accomplished. It requires more labour, more time, and it is costly, also for reducing this problem development of tractor operated seed ferti drill-cum-weedicide applicator was essential which saves time, cost of production, and lobour by doing all operations in single stage.

CHAPTER II

REVIEW OF LITERATURE

This chapter deals with the review of different work carried out by different researchers regarding various types of seed drills, their construction and material used, as well as various other attachments attached to the seed drill as a combination work.

2.1 Performance of Seed Drill

Smith and Wilkes (1977) has given some guidelines for fabrication of seed box of a planter as the box should be made of sheet metal or fibre and should be of sufficiently large capacity. A tight fitting lid should be provided to keep out of rain. The grain feeds should be set in the bottom of the box. The accuracy of the planter depends upon the shape of hopper bottom and fullness of the hopper. A cone shaped hopper bottom causes the seed to gravitate in to the cells. Hence it should be preferred.

Wilkins *et al.,* (1983) conducted some study on six different grain drill openers, including deep furrow opener, disk and hoe type were field tested in a seed bed. Opener type significantly affect the seed distribution, soil moisture content and bulk density in the seed bed, which in turn affected wheat seedling emergence. The best emergence was produced with a modified deep furrow opener that placed over 70 per cent of the seed in contact with soil that contained more than the limiting water content.

Bosoi *et al.,* (1987) described the drive mechanisms used on sowing machines. In modern sowing machines, motion was transmitted to the sowing shaft of the grain and fertilizer hopper from the supporting transmission wheels or rollers. When there were drills with the seeding mechanism, for which the seed rate was adjusted by changing the length of the roller feed working length, motion was transmitted by gear or chain drives.

Srivastava (1990) stated that the method of hitching also affects the rate of sowing e.g. hitching too low till result the furrow openers and boots to drop seeds back upward to the ground line. Hitching too high cause the furrow openers, to sow the seeds forward and downward. Proper hitching not only drops seeds at correct depth but also prevents plugging of furrow opener with grass, dust and wearing of heads of boots.

Singh *et al.,* (1993) stated that shovels of seed cum fertilizers wear out very fast because of improper material and hardness of these components resulting in frequent stoppage of work and loss of time during peak season until replacement with new ones. Wear studies have been conducted on shovels of seed cum fertilizer drills. Wear test on five different samples of shovels, i.e., mild steel, spring steel, high carbon steel, coated mild steel and heat treated mild steel were conducted on the rotary soil bin for 100 h each. Loss in weight for each shovel due to wear was recorded. Three types of soil, i.e., light, medium and heavy soil were used for the wear tests. Based on comparative analysis, the heat treated mild steel shovel was best suited keeping in view the life of shovels as compared to other types of shovels.

Gupta and Unadi (1994) developed a seven row seed cum fertilizer drill with working width of 1.75 m to match a two-wheel tractor. The improvement was done in many components of the original machine. For each row of seed, there was a seed hopper, a 6 fluted seed metering roller, a double disc furrow opener and for each row of fertilizer there was a fertilizer hopper, a fertilizer agitator and hoe type fertilizer furrow opener. The fertilizer furrow opener frame was fixed to the seed furrow opener frame to place fertilizer 2 cm below seed level and 5 cm beside the seed. Two lugged ground wheels rotate the metering rollers and fertilizer agitators mounted over a common shaft. Each flute in metering roller could pick 3 to 6 seeds at a time. The machine was provided with a foot operated clutch to disengage the seed metering mechanism. The actual field capacity of the machine was about 0.3 ha/h at forward speed of 0.7 m/s. The field efficiency of machine was about 72.2 per cent. The ratio of established plants to seeds sown was about 86 per cent for paddy seeds.

Seed damage due to metering mechanism was nil.

Sharma *et al.*, (2001) tested the modified multipurpose sowing machine in the adopted villages. RH-30 variety of raya crop was sown with this machine. They reported that the crop yield ranged between 1200.0 to 1957.5 kg/ha (average 1386.55 kg/ha). The yields obtained were 10-15% higher than the traditional methods of sowing. Moreover, as reported by the farmers use of paired row planting of raya crop by tractor drawn ridger seeder resulted in 30-40% saving in irrigation water. It accomplished the sowing timely, even under stressed moisture condition. The seed germination under stressed moisture conditions was quite satisfactory.

Chaudhary *et al.,* (2003) compared the tractor operated seed cum fertilizer drill with two sowing methods for sowing sorghum crop. The field trials were conducted at soil moisture content of 25.70%. He found that in mechanized method seed cum fertilizer drill works better than traditional method i.e. tifan in respect of field efficiency, yield of grain, yield of fodder and cost of sowing per hectare. Result showed that in mechanized method the field efficiency was found to be 79% which was 24.05% more than traditional method, yield of grain in mechanized method was found to be 27.5 qt/ha which was 36.36% more than traditional method, yield of fodder was found to be 74.22 qt/ha in mechanized method which was 6.18% more than traditional method and the cost of sowing was more in traditional method than mechanized method.

Shukla *et al.,* (2003) developed a nine row direct drilling machine with notched double disc furrow opener. The machine was capable performing sowing operation directly without any prior field preparation in a clean field as well as in standing stubble condition. All the nine furrow openers were independently mounted on the frame with the advantage of keeping same seed placement depth even in an uneven field. Fluted rollers were used for seed and fertilizer metering. The machine can be operated with 30 and above HP tractor. It was found that the draft requirement for operating the machine was 30-40 per cent less than the no-till-drill with inverted T type furrow openers. The machine also allows higher ground speed for sowing operation while conserving soil moisture and minimizing soil and residue displacement for conservation compliance.

Chen *et al.*, (2004) evaluated the effect of soil conditions and drill configurations on the drill and crop performances. They reported that removing press wheels from the planting unit reduced the speed of seed emergence and the plant population in the normal and dry seeding condition, while removing the press wheels increased the speed of seed emergence in the wet soil condition. Removing the gauge wheel in the soft soil condition reduced the speed of seed emergence and plant population due to increased planting depth. They also noted that removing the press or gauge wheels reduced the crop yield in the dry and normal seeding conditions.

Afzalinia *et al.,* (2006) determined the overall performance index (OPI) of the most common models of grain drills in Iran including Hassia, Nordstone, Hamadan Machine Barzegar, and Keshtgostar under irrigated conditions. The OPI, parameters such as required draft, field efficiency, effective field capacity, uniformity of the seed planting depth, uniformity of the seed distribution, plant population, possibility of planting seed and fertilizer simultaneously, number of required labourers, the cost of operation, availability of furrower for irrigation and planted crop yield were determined for each grain drill tested. A randomized complete block design was used to analyze data of this study. Results showed a significant difference between the grain drills for uniformity of the seed planting depth and draft requirement. The Machine Barzegar grain drill had the best planting depth uniformity (81.9 per cent) and the highest draft requirement (7665 N). Comparison of the grain drills for OPI showed that the Hamadan Machine Barzegar grain drill had the highest OPI (0.91).

Karayel *et al*., (2006) studied the individual volume of fluted wheel metering systems each holding more than one seed. The seed drills provide random seed distribution. A prerequisite for the improvement of seed spacing was the fast and reliable evaluation of distribution accuracy in laboratory tests a high-speed camera system was used for evaluating seed spacing uniformity and velocity of fall of seeds. The performance of the high-speed camera system in terms of seed spacing evaluation was compared with sticky belt test stand, used as a reference. Identical seed patterns were evaluated applying both methods simultaneously using wheat and soybean seeds. The speed of the metering rollers of the seed drill was set at 10, 20, 30 and 40 rpm and that of the seed drill at a simulated travelling speed of 1 m/s. In general, the high-speed camera system worked well in obtaining the seed spacing and velocity of fall of seeds. In all the tests with the wheat and soybean seeds, the high-speed camera system did not miss any seed. The sowing uniformity of the seed drill as investigated was affected by the speed of the metering rollers. Coefficient of variation of seed spacing and coefficient of variation of velocity of fall of seeds decreased as the speed of the metering rollers increased.

Maheshwari *et al.,* (2006) evaluated the performance of the multi crop seed cum fertilizer drill over a 0.5 ha well prepared field at Etawah after paddy harvesting. The type of soil was silty loam having initial moisture content of 15.5 per cent and the bulk density of experimental plot after seedbed preparation was 1.39 g/cm^3. The average visible mechanical damage to wheat seeds was found nil. The average plant population (190 plants / m^2) of seed sown by multi crop seed drill was approximately 3 per cent higher than the plant population (185 plants/m^2) of seed sown by zero till seed cum fertilizer drill. The average yield of the plots sown by multi crop seed drill was 40.35 q/ha as compared to the average yield of 35 q/ha for whole farm area, which was sown by zero till drill. It was more advantageous to use the multi crop seed cum fertilizer drill than any other seed drill, as it could be used for seeding of different crops like wheat, pea, gram, mustard, green gram, etc.

Verma *et al.,* (2007) designed and fabricated the identified furrow opener such as shoe, shovel and inverted T types in the research workshop at CIAE, Bhopal, India. Prime considerations were given to minimum soil disturbance and reduced tendency for clogging. The material used for fabrication of furrow opener conformed to the standard and grades of IS 6813: 2000. The testing was conducted in the laboratory. The potential of the furrow opener were compared on the basis of the draft requirements, soil disturbances and seed emergence. The inverted T type furrow opener required the lowest draft of 32.12 kgf, minimum soil disturbances (4-5 cm) and minimum clogging as compared shovel and shoe type furrow opener. Seed emergence percentage per meter of row length was found highest for the inverted T opener (86.66 per cent) as compared to the shoe (70.90 per cent) and shovel (62 per cent) type furrow opener.

Verma *et al.,* (2014) developed and evaluated cultivator cum seed drill. The prototype cultivator-cum-seed drill was designed, fabricated and tested for sowing of paddy. The machine consisted of cultivator frame, tines, seed box, seed tubes, metering mechanism, power transmission unit, furrow opener and hitching attachments. The drawings were prepared using CAD software. At the average working speed of 3.8 km/h of tractor drawn cultivator, depth of operation was found 129 mm, average weeding efficiency was found 76.42 per cent, effective field capacity was found 0.826 ha/h with field efficiency of 87.40 per cent. The cost of operation and energy requirement of cultivator was found to be Rs 387 per ha and 241 MJ/ha respectively. The seed rate of cultivator-cum-seed drill was found to be 80.87 kg/ha when flute exposure was 15 mm. At the average working speed of 3.09 km/h, the effective field capacity of the cultivator-cum seed drill was 0.537 ha/h with field efficiency of 82.8 per cent. Average plant population per square meter was found to be 280. The cost of operation and energy requirement for cultivator-cum-seed drill was found Rs 591 per ha and 320.58 MJ/ha respectively.

Kannan *et al.,* (2014) stated that a multipurpose sowing machine is designed for small farmers to improve their productivity. In this machine a common seed storage place is introduced to reduce the cost of the machine. The existing sowing machine had the individual storage place and separate seed metering mechanism which leads to more cost. The drawbacks in the existing sowing machine are rectified successfully in our machine. It will be more useful for small farmers and the agricultural society. The cost of the machine comes around Rs 6000/-.

Gautam *et al.,* (2013) concluded that performance of the (multipurpose tool) MPT was found better than the corresponding traditional practices. This implement could save time, increased the efficiency and quality of operation. This implement is a versatile implement and can be used for several field operations by changing the attached implement only. The draught of all the tested implements was below the draught capacity of local bullocks.

Achutha *et al.,* (2016) stated that (multipurpose agricultural equipment) MAE is single system which can perform multi operations like Sowing, fertilizer Chemical sprayer, Weeding and inter cultivation. It can also be used for local transportation purpose as a bicycle. MAE will reduce external charges like fuels; electricity etc. and this will be helpful for poor farmers. MAE is a single system which contains multi attachments and can be easily assembled and dismantled comfortably. All the fasteners used in the equipment are of the same size. The equipment weight is around 8 to 10 kg (Excluding bicycle attachment) thus it can be carried easily in farmland. The equipment can do the work of 4 labors a day which reduces the labor cost of the farmer.

2.2 Performance of Planter

Ozmerzi (1986) compared the seed distribution performance of four different types of furrow openers of planter’s namely single disc, double disc, hoe and shoe type furrow openers. He reported that depth distribution and transverse width of the hoe type furrow opener was better than the other type of furrow openers.

Altuntas *et al.,* (2006) studied the effects of different types of furrow openers and operation speed on soil properties, draft force and percentage of emerged tuber seedling by using a full automatic planter. The experiment was conducted on a clay-silt textured soil using hoe, shoe and shovel type furrow openers with 2.02, 3.28 and 4.50 km h^{-1} operation speeds, respectively. After planting soil penetration resistance, ridge height, mean emergence dates and percentage of emerged tuber seedling were determined. Soil penetration resistance increased with increasing operational speeds for each furrow opener type. The draft force requirement of furrow openers increased with operation speeds. Percentage of emerged tuber seedling was between 66.37 and 82.67 per cent, based on furrow opener type and operational speeds. The lowest soil penetration resistance, draft force and high percentage of emerged tuber seedling occurred with shovel type furrow opener.

Khambalkar *et al.,* (2014) studied the performance of broad bed-furrow planter in winter season of dry land crops at Dr.P.D.K.V. Akola and concluded that, there was an increase in yield 12.50% and 10.71% in chickpea and safflower, respectively using BBF planting method compared with the traditional flatbed method of sowing. The BBF method was more feasible than the traditional method of sowing for selected crops.

2.3 Combination Tool

Kumar *et al*., (2002) conducted an experiment on techno-economic evaluation of seeding technique in wheat crop. Evaluation of raised bed system for wheat crop over existing method was undertaken to optimize furrow and bed dimension with respect to crop parameters. There was no significant effect of method of sowing on seed germination and crop stand, but, yield attributes, namely, number of ears/m length and 1000 grain weight were significantly higher in crop sown with bed planter. Slightly higher grain and straw yields were recorded in flat system (36.42 q/ha and 63.82 q/ha) as compared to bed planter (34.79 q/ha and 58.40 q/ha). There was 41.5%saving in irrigation water and 25.41% reduction in cost of operation. The energy required per quintal of grain produced was also significantly lower in bed planter (33.2%) as compared to flat method.

Tahir Wahid *et al*., (2003) conducted experiment on scope of zero till seed cum fertilizer drill in dry land wheat crop production in Kashmir valley. They concluded that there was significant difference in the bulk density under zero tillage and conventional tillage system. More depletion of soil moisture by the crop at harvesting stage was observed in zero- tillage system in comparison to conventional tillage system. Better germination and tillers were observed under zero tillage system due to proper moisture at sowing time. The grain yield was found almost equal under both the system. The energy requirement and cost of operation were 4.45 and 3.65

times lesser in zero tillage as compared to conventional tillage system, respectively.

Singh (2007) stated that the seed metering device was usually actuated by the ground driven wheel which transmits power by means of a suitable device, i.e., chain-sprocket, belt-pulley or gear drive to achieve uniform delivery rates. There were different types of ground wheels to be used on drills depending on the ground conditions. When ground wheel carries the weight of machine as well as the seeds and fertilizers stored in boxes, the load on the wheel was sufficient to enable the power transmission from the wheel to the metering device. Two types of wheels i.e., pneumatic and rigid steel wheels were most commonly used in seed drills and planters. Rigid steel wheels were most commonly used because of their low cost, low maintenance and long life.

Vatsa and Sukhbir Singh (2010) conducted experiment on sowing methods with different seed drills for mechanizing mountain farming. They concluded that the effective field capacities were 0.039, 0.036, 0.120, 0.035, and 0.024 ha/h with field efficiency of 65.2, 63.3, 69.1, 65.1, and 57.4 with manual seed drill, manual multi crop planter, power tiller multi crop planter, dropping seed behind hand plough and sowing behind animal plough, respectively. The labour requirement was higher for hand plough and sowing behind plough than that of seed drills. The cost of operation was 2-4 times lower by using seed drills and planters. The yield of wheat was significantly higher than with seed drills and planters compared to the traditional method. Due to more fatigue, it was suggested that power operated equipment was better than manual operated method for sowing.

Ram and Singh (2011) conducted an experiment on four sowing methods namely raised bed planting, raised broad bed planting, ridge-furrow sowing and flat sowing for soybean crop. The highest seed yield was recorded in raised bed sowing, which was 6.70 and 5.29% higher than ridge furrow and flat sowing methods, respectively.

2.4 Spraying and Weedicide Application

Bisen and Srivastava (1985) measured spray uniformity pattern of wide swath spray boom in combination with two foot pumps by operating the system at a pressure of 350 kpa. The angle of rear and front nozzles of the spray boom were varied as 15, 20, 22, 25, 30 and 30, 35, 38, 40 and 45 degrees respectively with different nozzle tip setting in order to find out the best combination for uniform spray pattern. It was found that settings of 22° rear nozzle angle with tip fully tight and 48° front nozzle angle with tip one round open gave a swath width of 10.5 m. The rate of liquid discharge at this combination was 93 l/h.

Kharde and Gedam (2001) tested bullock drawn traction sprayer, which designed and developed by M/s Padsons Industries Akola. The sprayer has boom length of 520 cm consisting eight nozzles at adjustable spacing. It consists of two-piston pump powered by pulley and V-belt drive with separate pressure chamber. It was observed that the application rate of boom sprayer was 400 l/ha. The actual field capacity of sprayer was 0.88 ha/h. The optimum working pressure for efficient operation for sprayer was 4 kg/cm^2. Nozzle is a most important part of any sprayer. Selection of better nozzle helps in better performance of a sprayer. Commercially available nozzles like triple action, Italian turbo nozzle and spinning disc atomizer were compared by Jain (2002). It was found that with increase in pressure from 150 kPa to 350 kPa, droplet size (VMD) decreased from 192 to 185 μm in case of triple action nozzle and 284 to 276 μm in case of Italian turbo nozzle. For spinning disc atomizer droplet size decreased from 185 to 115μm with the increase in disc speed from 2000 to 4000 rpm. The mean droplet density for Italian turbo, triple action nozzle and spinning disc atomizer were 141, 81 and 7 per sq. cm. respectively.

Prokop and Kejklicek (2002) studied the effects of adjuvants on spray droplet sizes. Adjuvant (Ekol 90% raps fluid, 10% polyetoxyl esters and Agrovital 96% pinolene) was used to determine these effects using flat fan and low drift nozzles. Adjuvant increased the droplet size and decreased the percentage of small droplets for all nozzles.

Spray pattern of different nozzles like hollow cone, solid cone, adjustable and fan type nozzles were studied by Singh *et al* (2002). No definite pattern was found for the uniformity of spray distribution for all different nozzles at any particular angular setting and pressure. But with increase in pressure, discharge rate, swath width and working width increased for all the nozzles. For uniform spray at operating pressure 3.0 kg/cm^2 the nozzle spacing of the hollow cone, solid cone, adjustable and fan type nozzles were found to be 48, 42, 42 and 30 cm respectively.

Gupta (2003) developed a bullock drawn traction sprayer considering agronomical of physical economical considerations. The performance of sprayer was evaluated for different parameters in laboratory of field conditions pressure 3.5 kg/cm^2 the average boom discharge was observed at 2.47 l/min and 2.53 l/min in laboratory and field conditions respectively. The average horse power required to operate the machine was 0.486 hp, which was well within pulling capacity of bullocks. The average field capacity of sprayer was 0.704 ha/hr, which was almost seven times than that of knapsack sprayer.

Ejaz *et al.,* (2004) conducted studies on self-leveling boom sprayer. Self-leveling boom sprayer was tested at 250, 300 and 350 kPa pump pressure for different height of cotton crop. They concluded that discharge of a nozzle was a function of pressure, shape, size and design. Pressure had significant effect on spray angle, swath width, spray distribution, droplet size and discharge. Variation in discharge and spray angle was less along the boom at nozzle pressure of 350 kPa as compared to 250 and 300 kPa.

Saha *et al.,* (2004) evaluated tractor operated aero blast sprayer, power knapsack sprayer and manually operated sprayer in laboratory and orchard. It was found that tractor operated aero blast sprayer produced smallest droplet size of 254 μm with better penetration of spray droplets into the canopy. It was having highest field capacity of 1.54 ha/h with lowest man-power requirement of 1.95 h/ha.

Vidhale *et al.,* (2004) compared air assisted boom sprayer with lever operated knapsack sprayer for spraying on cotton crop. They found that operating cost of air assisted sprayer was Rs. 76.32/ha and for lever operated knapsack it was Rs. 260/ha. The time saving in case of air assisted sprayer was 89.11% and cost saving was 71% over lever operated knapsack sprayer.

Lijun *et al.,* (2006) observed that the forward speed had significant influence on droplet transport time as compared to liquid pressure. Hollow cone nozzles on the boom sprayer showed the highest potential drift compared with a flat fan nozzle, a low drift nozzle and an air inclusion nozzle. Spray deposition results indicated that accumulated deposition at peak point was 37.1%, 33.6% and 29.2% of the total deposition with flat fan, low drift nozzle and hollow cone nozzle, respectively.

Singh *et al.,* (2006) studied the performance of Triple action, Bi-action and hollow cone nozzles. The experiment was conducted at different settings of pressure, height and nozzle spacing in which pressure was 2.5, 3.0, 3.5 and 4.0 kg/cm^2, height was 45, 50 & 60cm whereas nozzle spacing was 40, 45 & 50cm. It was concluded that better spray distribution was obtained with triple action and bi-action nozzles as compared to hollow cone nozzle for all the four pressures. The bi-action nozzle gave best results at the pressure of 3.5kg/cm^2 with least coefficient of variation.

Comparison between air-assisted boom sprayer and traditional boom sprayer to check the spray applications in terms of quality and efficacy of distribution was done by Ade & Rondelli (2007). They found that the air-assisted overleaf treatment on a well-developed canopy showed 18% higher deposition and had 37% less losses to the ground when compared to a traditional treatment without air-assistance. Spray distribution at different heights showed that air-assisted treatments gave better uniformity compared to the traditional treatment.

Souza *et al.,* (2007) studied spray deposition and drop patterns from different nozzles. Deposition and efficiency on cotton plants were evaluated under different spraying patterns and nozzles (hollow cone, flat fan and double flat fan). The variability of deposits on the plants decreases from base to apex. Small droplets caused more loss by drift and evaporation, hence usages of high volume for spraying application resulted better coverage and lower variations of deposition along the canopy. Flat fan nozzle (47.60%) gave highest deposition on plants followed by double flat fan (39.25%) and hollow cone (27.45%).

Tekade *et al.,* (2008) evaluated a tractor mounted tall tree air carrier sprayer for spraying. It was found that spray swath and horizontal throw of air carrier sprayer increased with the increase in forward speed. The air carrier sprayer deposited spray uniformly on inner and outer side of tree at different locations.

Singh *et al.,* (2010) developed a tractor mounted air-assisted sprayer and compared with the conventional tractor mounted sprayer in cotton field. They found that at the forward speed of 4.0 km/h the uniformity coefficient (VMD/NMD) for the air-assisted sprayer was better (1.69) than for conventional sprayer (2.04). It was found that due to air-assistance, the sprayer was able to put an effective number of drops per square centimeter area on the underside of leaves at any section of the plants.

Effect of air velocity, leaf area density, nozzle pressure and forward speed on deposition characteristics of an air assisted spraying system was studied by Gupta *et al* (2011) on a simulated crop canopy. Droplet size and droplet density on under side of the canopy were less than that on the upper side. Droplet density increased with increase in air speed. Droplet density decreased with increase in leaf area density and forward speed. Forward speed and leaf area density did not influence the droplet size.

Jayashree and Krishnan (2012) developed a tractor operated target actuated sprayer to reduce the application of chemical, soil pollution and environmental pollution. It was concluded that delivery of minimum amount of chemical (499 μl) was achieved at 100 mm width of simulation plate with 3.5 km/h forward speed and sensor height of 300 mm above the plant canopy. Amount of chemical delivery decreased with increase in forward speed and height of sensor but increased with increase in width of simulation plate.

Sukumaran (2012) studied the effect of pressure on discharge rate and wear of hollow cone nozzle having different nozzle tip material. Three type of material in hollow cone nozzle such as brass, plastic and stainless steel were studied at three different pressure settings to assess its performance. It was found that with the increase of pressure and usage of the nozzle, discharge rate of nozzle increased. Average orifice hole diameter of all type of nozzle materials increased with increase in pressure and usage, but it was least in stainless steel followed by plastic and brass.

Hassen *et al.,* (2013) studied the effect of nozzle type, angle and pressure on spray volumetric distribution of broadcasting and banding application. Experiments were conducted on a spray patternator through even flat fan nozzle for banding application and standard flat fan nozzle for broadcasting application. Spray distribution was determined and compared by using single flat fan nozzle, at a height of 0.5 m under laboratory conditions. Effect of spray fan angles (65° and 80°) and liquid pressures (200 kPa and 300 kPa) on spray distribution was also examined. The best distribution of spray application was obtained by using banding nozzle. The broadcasting nozzle gave an uneven spray distribution. The combination of even flat nozzle TPE, nozzle angle 80° and nozzle pressure 300 kPa gave the best spray volumetric distribution and minimum coefficient of variations 42.73%. Even flat fan nozzle provided spray volumetric distribution better than standard flat fan nozzle. It was observed that by increasing nozzle angle and pressure the value of the coefficient of variation decreased.

Salyani *et al.,* (2013) assessed the spray distribution pattern with water sensitive papers. Results revealed that there was irregular deposition on very lightly and very heavily strained targets (area coverage 0-5% & 80-100%) with nearly negligible correlation between area coverage and spray deposition. However due to settling of large droplets before reaching the target, number of droplet strains get lower for more distant targets. Wide range of water sensitive paper coverage in field spray particularly in high volume appeared that water sensitive paper could not provide accurate information for assessing the amount of spray deposition.

CHAPTER III

MATERIALS AND METHODS

In this chapter, the methods considered in design, constructional details of different components along with their specifications, machine drawings and photographs and materials used in development of tractor operated seed ferti drill-cum-weedicide applicator are explained sequentially. Based on optimal design values, weedicide unit of tractor operated seed ferti drill-cum-weedicide applicator was fabricated and evaluated the performance in the field. The present study was carried out in Central Demonstration Farm in Wani -Rambhapur under Dr. PDKV Akola.

Any type of machine or mechanism requires a number of elements, which were so designed that they withstand safely against the forces to which they were subjected, so that they can perform their functions without failure or undue distortions.

3.1 Design Considerations

A due attention was provided on the following design aspects while fabrication of tractor operated seed ferti drill-cum-weedicide applicator. i.e. weedicide application system.

- Agronomical requirements.
- Physical and economical considerations.

3.1.1 Agronomical requirements

A machine was designed by keeping its spacing and number of rows to be sprayed.

3.1.2 Physical and economical considerations

- Machine should be simple in design and it should be easy to operate.
- Cost of the machine should be low.
- It should be easily repairable by farmer or village artisans.
- The total power requirement should not exceed the power available from available tractors (45 hp).
- Machine should be light in weight

3.2 Design of Frame for Lifting the 200 lit Tank

Taking into consideration the weight of tank and liquid to be filled inside tank, the frame was designed to sustain the weight. The specification of the frame are 1600 x 580 x 610 mm with thickness 5 mm m. s. angle iron were used to develop a frame as shown in Fig. no. 3.1. Side support were also given taking into consideration the dynamic weight of weedicide in the tank.

In engineering practice, the machine parts of structural members may be subjected to static or dynamic loads which causes bending stress. Consider a straight beam subjected to a bending moment *M* as shown in Fig.3.1 A little consideration will show that when angle is subjected to the bending moment. The bending equation is given by

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R} \qquad ---- \qquad 3.1$$

Where,

M = Bending moment acting at the given section,

σ = Bending stress,

I = Moment of inertia of the cross-section about the neutral axis,

y = Distance from the neutral axis to the extreme end,

E = Young's modulus of the material of the angle, and

R = Radius of curvature of the angle.

$$\text{Factor of safety} = \frac{\text{maximum stress}}{\text{working stress}}$$

Bending moment (M) = W x L

Where,

W= Weight, N

L= Length, mm

Fig. 3.1 Frame of weedicide tank

3.3 Weedicide Tank

The HDPE tank of capacity 200 litter size was purchased from the market for storing the weedicide. The weedicide tank is rectangular in shape fitted in the frame for the supporting tank. The purchase prize of the weedicide tank from market was Rs.1800. Dimension of the weedicide tank has length 860 mm, width 640 mm, and height 440 mm. Weedicide tank opens at upper side having rectangular section of size 300 mm length and 200 mm width. At the bottom side of weedicide tank the pipes were is attached. Upper side of tank has one hole for overflow of the weedicide from HTP pump having the diameter of the hole as 20 mm in Fig.3.2

Fig. 3.2 Weedicide tank

3.4. Hoses

Three hose pipes were used in tractor operated seed ferti drill-cum-weedicide applicator. The diameter of three hose pipe was 20 mm. One hose having its length 1200 mm was attached to wedicide tank to HTP pump for suction of the weedicide from tank with the help of HTP pump. Another hose having length 1800 mm was used work for the overflowing of the weedicide into the tank and this hose was used for flowing of weedicide to the spraying unit of weedicide frame having nozzle.

3.5. Supporting Frame of HTP Pump

The supporting frame of HTP pump was made up of cast iron. Specifications of supporting frame are height is 860 mm and width of frame 270 mm. Total height of frame is 930 mm Fig.3.3

Fig. 3.3 Supporting frame of HTP pump

3.6. Length of Belt

Two belts were used to transmit the power from PTO to HTP pump i.e. A-87 type belt is used. The belt length was 2400 mm and thickness was 20 mm.

Design length of the belt

Consider,

r_1 and r_2 = Radii of the larger and smaller pulleys,

x = Distance between the centers of two pulleys,

L = Total length of the belt

d_1 and d_2 = Diameter of larger and smaller pulley

Length of belt = $\frac{\pi}{2}(d1 + d2) + 2x + \frac{(d1 - d2)^2}{4x}$ ------- 3.2

3.7. Diameter of Pulley

The pulleys are used to transmit power from one shaft to another by means of flat belts, V-belts or ropes. The pulleys may be made of cast iron, cast steel or pressed steel. The cast materials should have good friction and wear characteristics. There are two pulleys in weedicide applicator made from cast iron. One pulley attached to PTO and another pulley attached to HTP pump. Diameter of HTP pump is 110 mm and diameter of PTO pulley is 170 mm.

Design of Pulley

The diameter of the pulley (D) may be obtained either from velocity ratio consideration or centrifugal stress consideration. We know that the centrifugal stress induced in the rim of the pulley,

$$\sigma t = \rho.V^2 \quad \text{------} \quad 3.3$$

where,

ρ = Density of the rim material

= 7200 kg/m^3 for cast iron

V^2= Velocity of the rim

= πDN / 60, D being the diameter of pulley and

N is speed of the pulley.

Fig. 3.4 PTO Pulley

3.8. PTO of Tractor

The power take-off (PTO) shaft is an efficient means of transferring mechanical power between farm tractors and implements. A rigid guard fitted on tractor covers the power take-off shaft as a safety device. This guard is called power take-off shield. Agricultural machines are coupled with this shaft at rear part of the tractor. As per ASAE standard PTO speed is 540 ±10 rpm when operating under load.

3.9.Seed Ferti Drill

3.9.1 Functional components of the machine

This seed drill consists of the following functional components.

1. Main frame
2. Tynes
3. Furrow openers
4. Ground wheel
5. Hitching unit
6. Seed cum fertilizer box
7. Seed tube
8. Drives for metering device
9. Weedicide sprayer unit

10. Seed covering blade
11. HTP pump supporting Frame
12. Tank supporting frame

Table. 3.1 Specifications of seed cum fertilizer drill

Sr. No	Particulars	Seed drill cum fertiliser with seed covering device
1	Frame size, mm	2550×1850×450
2	Type	Tractor operated,5 row
3	Power source	45 hp Tractor
4	Total weight of seed cum fertilizer drill, kg	330
5	Tyne to tyne distance, mm	450
6	Seed metering device	Fluted roller mechanism
7	Fertilizer metering mechanism	Fluted feed roller
8	Seed type	All type of seeds
9	Furrow opener	Shovel type
10	Power transmission in seed drill	From ground wheel through sprocket & chain arrangement
11	Power transmission to sprayer	Tractor PTO
12	Hopper dimensions, mm	1840 x 450 x 260

3.9.2 Main frame

Seed box, soil cutting units, furrow openers, hitching unit, seed covering device and depth control wheels were mounted on the main frame. The frame has provision for attachment of replaceable parts such as control wheel, and furrow openers. The size of main frame is 2550 ×1850 × 450 mm and made from M.S angle of 50 × 50 × 4.5 mm as shown in Fig.3.5

Fig. 3.5 Main frame of seed drill

3.10 Sowing Unit

3.10.1 Seed cum fertilizer box:

The seed box is to carry the seed and meter it in to the metering mechanism. Seed box was trapezoidal in shape. The accuracy of the seed drill depends upon the shape of hopper bottom and fullness of the hopper (Smith and Wilkes, 1977). The seed cum fertilizer box is made up of M.S. Sheet. Two separate compartments for seed and fertilizer were done. The overall dimensions of the box for top length, total height and thickness are 1840 x 450 x 260 mm respectively.

3.10.2 Seed and fertilizer metering mechanism:

The metering mechanism for seed drill chosen was fluted roller. Fluted roller metering mechanism is a more positive metering device.

Seed metering device had the following components

i. Fluted rollers
ii. Flow control tongue
iii. Seed adjustment lever

Fluted feed roller seed metering mechanism was used in the design because control of plant to plant spacing was not needed. Fluted rollers made up of cast iron facilitates continuous seeding of seeds. The rollers were fitted in a series on a shaft.

Below the fluted roller, an aluminum tongue was provided to hold the seed. The tongue can be raised or lowered depending on the size of the seed. The seed metering of fluted roller type mechanism was used to meter the seeds from the seed box. It had an adjustment of adjusting seed rate as per the crop to be sown.

3.10.3 Seed tube and funnel

Seed tubes were fitted to carry the seed metered from fluted roller, up to boot portion of furrow openers with shortest route of seed travel and minimum obstacles in flow path for easy flow of seed. A transparent flexible plastic seed tube of 20 mm diameter and 600-700 mm in length was chosen. GI funnels were fitted on the fluted rollers. To minimize obstacles in seed flow path, end of funnel was inserted inside one end of this transparent flexible plastic tube and another end of this transparent flexible plastic tube itself was inserted inside the boot of furrow opener.

3.10.4 Tyne

Tynes are made up of MS flat of thickness 20 mm (Fig 3.6). The length of tynes is 410 mm and width 76 mm. MS flat of size 182 x 100 x 10 mm was welded at top side for clamp attachment with four 17 mm diameter holes. Total five numbers of tynes were attached to the frame with the help of clamps and nuts. Clamps were provided so that spacing between tynes can be adjusted.

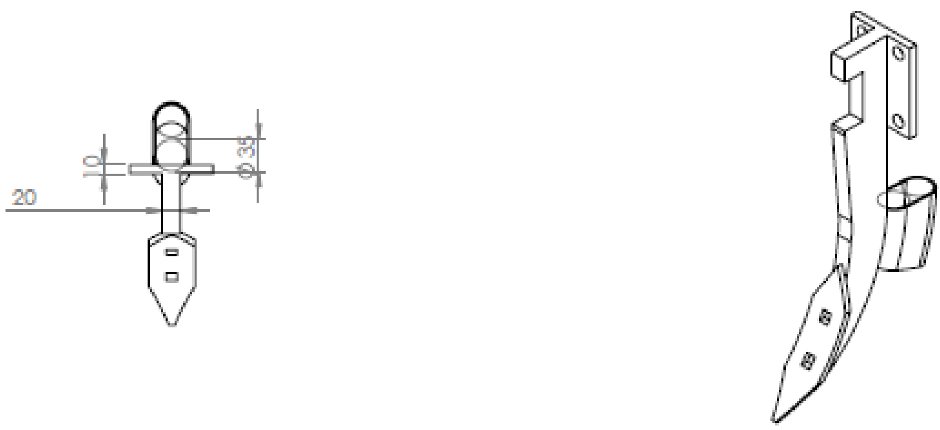

Fig. 3.6 Schematic view of tyne

3.10.5 Furrow openers

The shovel type furrow openers which are best suited for Vidarbha region were employed in this seed drill. These furrow openers are suitable for light medium soil free of excessive trash and it has good soil penetration.

3.11 Power Transmission Unit

3.11.1 Ground wheel

The diameter of ground wheel was 280 mm to achieve required plant spacing, ground clearance of machine and height of seed dropping. The ground wheel diameter was selected on as per seed rate method and mainly based on machine height. Spokes of 16 mm were used to the ground wheel.

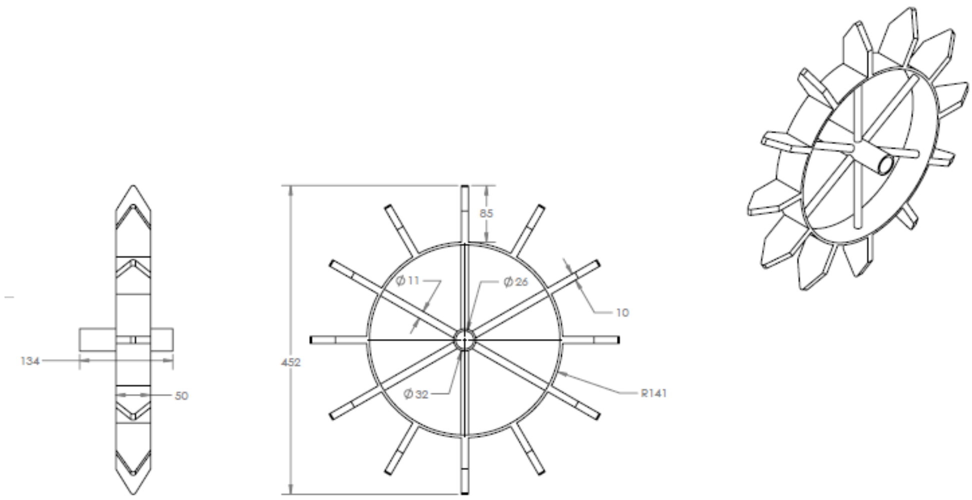

Fig. 3.7 Schematic view of ground wheel

3.11.2 Seed covering device

A covering device was connected behind furrow openers to cover the seed with soil. The seed covering is very much important since it covers seed after sowing and protects it from birds and also gets moist surrounding soil for quicker germination. The 1800 x 70 mm blade of cast iron was used for seed covering device.

3.11.3 Metering device:

The power from ground wheel was transmitted to the metering device by means of chain and sprocket arrangement. It consists of following parts:

1. Sprockets: 6 sprockets of 17 teeth
2. Chain: 3 chains of 1m, 1.5 m length
3. Transmission shafts: Two transmission shaft of diameter 35 mm
4. Bevel gears: Five pairs of 1:1 power transmission ratio

Fig. 3.8 Tractor operated seed ferti drill-cum-weedicide applicator

1.Tank 2. HTP Pump 3. Seed cum fertilizer box 4. Nozzle frame 5. Ground wheel 6. Weedicide pipe 7. Overflow pipe 8. Tank supporting frame

3.12 Frame for Nozzles

The frame nozzle (Fig.3.9) was made from the m.s angle 40 x 50 x 5 mm.Total length of the nozzle frame was 2970 mm. Four flat fan nozzles were attached to the nozzle frame. Distance between the two nozzle is 450 - 550 mm. The height of the nozzle frame from the ground is 500 mm.

Fig. 3.9 Frame for nozzles

3.13 Weedicide Applicator

3.13.1 Functional components of sprayer

1. Weedicide tank
2. HTP piston pump
3. Supporting frame of HTP pump
4. Pulley and belt
5. Hoses and nozzle
6. Supporting frame of weedicide tank

Table. 3.2 Specifications of weedicide applicator

Sr. No	Particulars	Sprayers specifications
1	HTP pump	Dual piston, Aspee, PS-26
2	Tank capacity, lit	200
3	Power transmission to pump	Tractor PTO
4	Hose pipes	Nylon material
5	Nozzles	Hollow cone type nozzle
6	No of nozzles	4
7	Nozzle to nozzle distance, mm	450
8	Nozzle discharge, l/m	1.98
9	Nozzle pressure, kg/cm^2	2.5
10	Frame Fittings	Nuts
11	Max height of nozzle from ground, mm	900-1200

3.13.2 HTP Pump

HTP, horizontal Triplex piston power sprayer unit, developing 28 kg/cm^2 pressure and giving free discharge of 24 lpm at 950 rpm, supplied with pulley, pressure vessel, pressure gauge. By-pass cum pressure regulator valve (CVA) was used as shown in Fig. 3.10

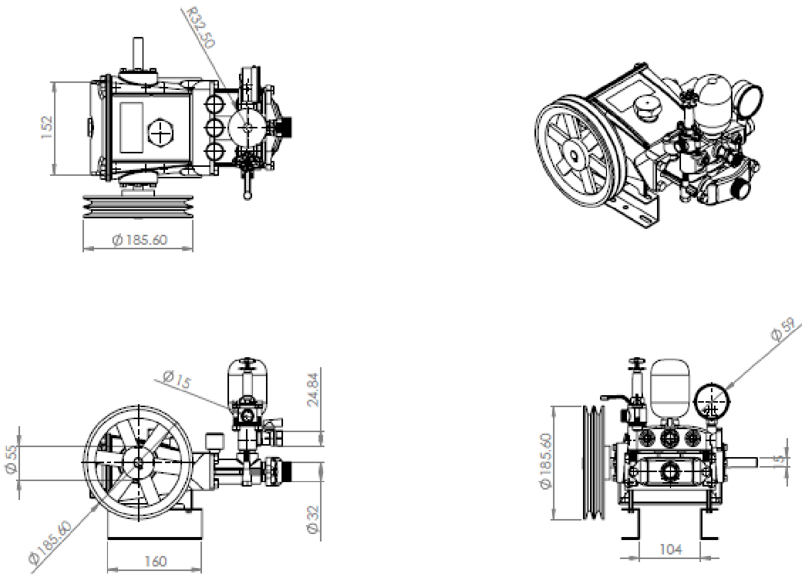

Fig. 3.10 Schematic view of HTP Pump

Table 3.3 Specifications HTP piston pump

Model	AS-26
Dry Weight (without pully & oil) kgs	9.6
Suction capacity (1/m)	24
Pump RPM	950
Pressure kg/cm^2 (max)	28
Pressure kg/cm^2 (working)	14
Power required, HP	3
Engine (Ps.)	3.5
L x W x H ,mm	320 x 240 x 395
Pump material	Brass

3.14 Discharge of Nozzle

To determine the nozzle discharge at 500 and 550 mm height. Because 500 mm height was the minimum height of weedicide applicator and maximum height was 550 mm. Weedicide applicator was operated at normal travelling speed of 3.5 km/h in the field area. Separate discharge of each nozzle and total discharge of the four nozzles in one minute was measured in measuring cylinder.

3.14.1 Laboratory evaluation of discharge of nozzles

The flow rate and spray width of a single nozzle was measured at three levels of spray pressure (14 kg/cm^2) and spray height (500 and 550 mm). The average value of three repetition tests was used as the representative value. In laboratory testing of weedicide applicator, discharge rate of single nozzle was calculated at height of 500 mm and 550 mm. The spray width of individual nozzle and average of the spray width of the four nozzles were observed and measured.

3.14.2 Field evaluation of discharge of nozzle

The flow rate and spray width of a single nozzle was measured at three levels of spray pressure (14 kg/cm^2) and spray height (500 and 550 mm). The average value of three repetition tests was used as the representative value. In field testing of weedicide applicator, discharge rate of single nozzle was calculated at height of 500 mm and 550 mm. The spray width of individual nozzle and average of the spray width of the four nozzles were observed and measured.

3.15 Nozzles

The spray boom constitutes the sprayer component part on which nozzles are fitted. Spray booms were designed to hold spray nozzles used in the spraying field crops. The main criterion in the boom influences the droplet size and volume of spray fluid required to cover a unit area. As rate of delivery from nozzles is constant, it is obvious that the ground speed will affect the machine application rate.

Hollow cone nozzles are most commonly used for weedicide application of crops. It produces finer droplets and spray penetrates better into plant foliage, suitable for low and medium volume applications. A minimum pressure is essential to provide sufficient velocity to overcome the contracting force, surface tension and to obtain full development of spray pattern. The minimum one bar pressure is required to operate these nozzles.

3.15.1 Spray angle

It is the angle subtended at the final orifice by the edge of the spray pattern and depends on discharge operating pressure, swirl plate and plate of swirl chamber. Spray angles of the nozzle at varying pressure were noted with the help of angle measuring instrument. The angle measuring instrument consist of two flat metal strips hinged at one end. The outer side of the strips was folded at right angle along their length. This angle was then measured with a protector. Spray angle increase with

i. Increase in orifice size
ii. Increase in operating pressure
iii. Decrease on size of swirl plate opening and
iv. Decrease in the depth of swirl chamber

3.15.2 Swath coverage width of nozzle

Four nozzles were used in weedicide unit for the application of the weedicide on the field at the time of sowing operation. Distance between the two weedicide unit of nozzle was 450 mm. The total width of the operation was 2320 mm.

3.15.4 Types of nozzles

There are three types of nozzles Out of which hollow cone nozzle was used for weedicide application.

Hollow cone nozzle

These is effective insect and disease control and where drift is not a major consideration. Hollow cone nozzle produced small droplet than other nozzles. It is used very effective for herbicide and weedicide spraying. These nozzle operate in pressure range 40 to 100 psi.

Fig. 3.11 Hollow cone nozzle

3.16 Weedicide

Pre-emergence and post-emergence weedicides are available in market. Pre emergence weedicide means that weedicide application at the time of operation of sowing of seed and post emergence weedicide means weedicide applied after the growth of the crop**.** Pendimethalin and S-metazachlor are pre emergence weedicide used at the time of sowing of crop and reduce the intensity of the weed growth of crop. The dose of pendimethalin was 2.5 l/ha for the weedicide application.

3.16.1 Application of weedicide

Pendimethalin weedicide mixed with 200 litre of water was used as chemical solution. Application of weedicide at the time of sowing operation. 2 litre pendimethalin used for 1 hactare area as per recommended dose. One ml pendimethalin mixed with 2 litre of water for weedicide application.

3.16.2 Time of weedicide application

At the time of sowing operation simulteneously seed covering and weedicide application was carried out.The seed covering operation by a special frame attachment on which nozzles were attached.

3.16.3 Time losses

Time taken in turning at the end of each row was observed and recorded. In cleaning and adjustment, the time of cleaning of nozzle and making some adjustment required during operation was recorded. In refilling of liquid the time required to refill the liquid in the tank was also recorded.

3.17 Calibration of Sprayer

The basic concept of calibration of sprayer is to establish rate of application of weedicide with respect pump

1) Calibration of time required for spraying for 1ha area
2) Spraying weedicide required for 1ha area
3) Calibrate on the basis of volume

3.18 Instrumentation for Research Work

Dynamometer was used to measure draft of the implement. Tape was used for measuring the distance of the walking track dimension. Weight balance was used to measure the weight of the seeds and Fertilizers. Steel scale measure depth of operation and Depth was measured at randomly selected spots. Stop watch was used to measure time for area covered, speed of tractor etc**.**

3.19 Experimental Procedures:

The fabrication of tractor operated seed ferti drill-cum-weedicide applicator was evaluated for its performance in laboratory and field. During the laboratory test; the main objectives of test were to record.

i. Specifications
ii. Checking of adjustments, provided.

3.19.1 Field test

The developed tractor operated seed ferti drill-cum-weedicide applicator was tested on the field at Central Demonstration Farm Wani-Rambhapur block of Dr. PDKV Akola. The laboratory trials were conducted at CDF workshop and field tests were conducted at farms of Wani-Rambhapur as shown in Fig.3.12

Evaluation parameter of the tractor operated seed ferti drill-cum-weedicide applicator are described below with methods of measurement for seed cum fertilizer drill, Sprayer, and seed covering blade.

Fig. 3.12 Field operation test at CDF Wani-Rambhapur farm

3.19.2 Field operational pattern

Field capacity and field efficiency were influenced by field operational pattern which was closely related to size and shape of field, size and type of implement. Actual width of operation of implement was measured at the time of operation. 0.60 ha area was selected for field test.

3.19.4 Speed of operation

Outside the long boundary of test plot, two poles were place at opposite ends. The time taken by tractor to travel distance between two poles enabled to determine the operating speed which is measured in km/h

3.20 Performance Evaluation Tractor Operated Seed Ferti Drill-Cum-Weedicide Applicator.

The field experiment was carried out at CDF Wani-Rambhapur block under Dr. PDKV Akola.

Experimental technique

The techno-economic feasibility of newly developed of tractor operated seed ferti drill-cum-weedicide applicator was evaluated by taking the field tests. The field tests were taken according to procedure described under following sections.

A) Soil parameters

1) Moisture content of the soil
2) Bulk density of soil

B) Machine and operational parameters

1) Speed of operation
2) Draft requirement
3) Theoretical field capacity
4) Effective field capacity
5) Field efficiency
6) Fuel consumption
7) Tractor wheel slip

The above parameters were evaluated for tractor operated seed ferti drill-cum-weedicide applicator during field trails.

3.20.1 Soil moisture content

Soil moisture content on the dry basis was measured as suggested by Mohsenin (1979) using oven dry method. Five samples of soil were collected randomly from test plots; the weight of each sample was taken by weight balance. It was placed in a hot air oven and maintained the temperature of 105 °C for 24 hours. The samples were taken out from oven and weighted using weight balance. The moisture content on the dry basis was calculated using following formula.

$$MC(db)\% = \frac{w_1 - w_2}{w_2} x 100 \qquad \dots 3.4$$

Where,

MC= moisture content, % dry basis

w1= initial weight of soil sample, gm

w2= weight of dry soil sample, gm

3.20.2 Bulk density

It is the ratio of the mass of soil sample to the volume of core cutter. The bulk density of soil was calculated by following formula.

$$\text{Bulk density}(gm/cm^3) = \frac{\text{Mass of soil sample}}{\text{Volume of core cutter}}$$

$$\rho = \frac{M}{\pi D^2 L} \qquad \dots 3.5$$

Where,

P = bulk density, gm/cm3

M = borne dry weight of soil sample, gm

3.20.3 Speed of operation

For calculating traveling speed two poles 20 m apart were placed approximately in the middle of the test run. On the opposite side also two poles were placed in similar position, 20 m apart so that four poles form corners of the rectangle, parallel on a long side of the plot. The speed was calculated from the time required for the machine to travel the distance (20 m) between two poles. Average of such reading was taken to calculate the traveling speed of the machine.

$$S = \frac{L}{t} \quad ...3.6$$

Where,

S = forward speed of the machine, m/s

L = distance traveled, m

t = time taken, s

3.20.4 Draft of Implement

The draft measurement was done with the help of digital meter with a load cell. The 'X' tractor along with dynamometer was positioned in front of the test tractor (Y) and the dynamometer was connected to the front axle of 'Y' tractor with wire rope and clamps. Wire rope and dynamometer was kept horizontal during the field trial and the implement was attached to the 'Y' tractor. The draft of implement was recorded in the field. For no-load reading, the implement was lifted and the draft was recorded, similarly, draft reading recorded while machine in operation. Throughout the dynamometer reading the tractor 'Y' was kept in neutral position. The readings were noted after each run. The results of the draft requirement of implement were calculated by following formula (Mehta *et al.,* 2005).

Draft of Implement = with load draft – without load draft ….3.7

3.20.5 Effective field capacity

For calculating effective field capacity, the time consumed for actual work and lost for other activities such as turning were considered.

Effective actual field capacity was calculated by following formula (Mehta *et al*., 2005).

$$E.F.C = \frac{A}{T_P + T_1} \quad ...3.8$$

Where,

E.F.C = effective field capacity, ha/h

A = area, ha

T_p = productive time, h

T_1 = non-productive time, h

3.20.6 Theoretical field capacity

For calculating the theoretical field capacity, working width and traveling speed was taken into consideration. It is always greater than the actual field capacity.

Theoretical field capacity was calculated by using following formula (Mehta *et al.,* 2005)

$$T.F.C = \frac{S \text{ x } W}{10} \qquad \text{...} 3.9$$

Where,

T.F.C = Theoretical field capacity, ha/h

W = Theoretical width of Implement, m

S = Speed of operation, km/h

3.20.7 Field efficiency

Field efficiency was calculated by taking the ratio of effective field capacity to theoretical field capacity. It is always expressed in percentage. It was calculated by following formula (Mehta *et al*., 2005).

$$FE = \frac{EFC}{TFC} \text{x} 100 \qquad \text{...} 3.10$$

Where,

FE = Field efficiency, %

EFC = effective field capacity, ha/h

TFC = theoretical field capacity, ha/h

3.20.8 Fuel consumption

To measure the fuel consumption, the tractor was placed on the leveled ground. Then fuel tank of the tractor was filled up to top of the tank before the operation. After the completion of the operation tractor was placed at a leveled ground and then the tank was again refilled with fuel to maintain the original level of fuel. The quantity of fuel filled in the tank was measured by measuring cylinder. The quantity of fuel required to make up the original level as before the operation was the actual fuel consumption.

3.20.9 Tractor wheel slip

The tractor drive wheel normally slips in all field operations. The tractor wheel slip depends upon the depth of operation and moisture content of the soil. The determination of per cent tractor wheel slip was useful to know the approximate loss of power from the ground during actual field operation. The slip will affect the speed of operation and thereby the effective field capacity of the implement. The tractor wheel slip was determined in percentage by using following formula.

$$\text{Wheel slip, \%} = \frac{N_2 - N_1}{N_2} x100 \qquad \ldots 3.11$$

Where,

N_1 = No. of revolutions of tractor wheel without load

N_2 = No. of revolutions of tractor wheel with a load

3.21 Cost Economics of Tractor Operated Seed Ferti Drill-cum-Weedicide Applicator

Method of determining fabrication cost of the developed implement, cost of operation per hour and cost of operation per hectare are given in detail in this section. Calculations are given in Appendix-C

Determination of cost of operation per hour of tractor operated seed ferti drill-cum -weedicide applicator

The cost of operation of tractor operated seed ferti drill-cum-weedicide applicator is the addition of cost of operation of tractor and cost of operation of the implement. The cost operation was calculated using the standard procedure. The total cost of operation per hour consists of fixed cost and operating cost.

A. Fixed cost includes

1) Depreciation
2) Interest
3) Housing
4) Insurance
5) Taxes

B. Operating cost includes

1) Fuel cost
2) Lubricant cost
3) Repair and maintenance cost
4) Wages

C. Total cost (A + B)

A. Fixed cost per hour

It was calculated by taking a total of following costs.

1) Depreciation

It is a loss of value of tractor and implement with the passing of time and was calculated by following formula.

$$D = \frac{P - S}{L \times h} \qquad \ldots 3.12$$

Where,

D = Depreciation per hour

P = Purchase price or capital investment

S = Salvage value which is 10 per cent of the purchase price

L = Total life of tractor and implement in years

h = No. of working hours of the tractor and implement per year

2) Interest

It was calculated on the average investment of the tractor and implement by taking into consideration the value of the tractor and implement in first and last year and was calculated by following formula,

$$I = \frac{P + S}{2} \times \frac{R}{100 \times h} \qquad \ldots 3.13$$

Where,

I = Interest to be paid per hour

R = Rate of interest per year

3) Housing

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

$$I = \frac{P}{h} x \frac{1}{100} \qquad \ldots 3.14$$

Where,

h = Housing cost per hour (taken 1 per cent of purchase price)

4) Insurance

For a tractor, it is taken as one per cent of purchase price and for the implement, insurance charges were taken as nil.

5) Taxes

For a tractor, it is taken as one per cent of purchase price and for the implement, taxes were taken as nil.

B. Variable cost

It includes a total of following costs.

1) Fuel cost

It includes actual cost paid for fuel during operation of the tractor. To implement fuel charges were taken as nil. No fuel charges were consider for implement.

2) Lubricants cost

For the tractor, it is taken as 10 per cent of fuel cost and for the implement, it was taken as Nil.

3) Repair and maintenance cost per hour

Repair and maintenance cost varies between 5 to 10 per cent of the initial cost per year. Here, it was considered 8 per cent of the initial cost and calculated as.

$$R\&M = \frac{8 \text{ x } P}{100 \text{ x } h} \qquad \ldots 3.15$$

4) Wages of operator per hour

As one skilled labour was required for operating tractor operated seed ferti drill-cum-weedicide applicator, the charge per hour was calculated by considering current labour charges.

3.21.2 Determination of cost of operation per hectare of tractor operated seed ferti drill-cum-weedicide applicator

The total cost of operation of the developed implement in Rs /ha was calculated by using following formula.

$$\text{Cost of operation, (Rs/h)} = \frac{\text{Cost of operation of implement, (Rs/ha)}}{\text{Effective field capacity of implement, (ha/h)}} \quad \ldots 3.16$$

CHAPTER IV

RESULTS AND DISCUSSION

This chapter discusses about the results of performance evaluation of tractor operated seed ferti drill-cum-weedicide applicator. The implement was tested in the laboratory as well as in the field to evaluate its overall performance. The tractor operated seed ferti drill-cum-weedicide applicator developed was tested on the field of CDF Wani-Rambhapur block of the Dr. PDKV, Akola. The performance results of seed ferti drill-cum-weedicide applicator were observed by conducting field trials for sowing chick pea variety, Rajvijay-203 and the results were tabulated in organized manner to evaluate the performance.

4.1 Performance and Evaluation Of Tractor Operated Seed Ferti Drill-cum-Weedicide Applicator

The tractor operated seed ferti drill-cum-weedicide applicator was tested for different parameters such as speed of operation speed, draft, working depth, working width, field efficiency, effective field capacity, theoretical field capacity, nozzle discharge, spray angle, fuel consumption and wheel slip.

4.2 Discharge of Nozzles

4.2.1 Laboratory evaluation of discharge of nozzles

In laboratory evaluation of the weedicide applicator it was observed that at height of 500 mm average discharge of the nozzles was 1.91 l/min with pressure 14 kg/cm^2 and average spray width of the nozzles was 563 mm. At height of 550 mm average discharge of nozzles was1.92 l/min at same pressure and average swath width of the nozzles was 564.75 mm.

Table 4.1 Discharge rate of nozzle at height 500 mm

Height, mm	Nozzle	Discharge, l/min	Pressure, kg/cm^2	Spray width, mm
500	N1	1.85	14	564
	N2	1.87		561
	N3	1.99		562
	N4	1.95		565
	Average	**1.91**		**563**

In Table 4.1 laboratory evaluation of weedicide applicator discharge rate and spray width of four different hollow cone nozzles were calculated at the pressure of 14 kg/cm^2 and height of 500 mm. The results indicated that the average discharge rate of nozzles was 1.91 l/min at the pressure 14 kg/cm^2 and average spray width was 563 mm.

Table 4.2 Discharge rate of nozzle at height 550 mm

Height of nozzle, mm	Nozzle	Discharge of nozzle l/min	Pressure, kg/cm^2	Spray width, mm
550	N1	1.98	14	564
	N2	1.92		566
	N3	1.90		565
	N4	1.89		564
	Average	**1.92**		**564.75**

In Table 4.2 laboratory evaluation of weedicide applicator, discharge rate and spray width of four different hollow cone nozzles was calculated at the pressure of 14 kg/cm^2 and height of 550 mm. The results indicated that and the average discharge rate of nozzles was 1.92 l/min at pressure 14 kg/cm^2 and average spray width was 564.75 mm.

4.2.2 Field evaluation of discharge of nozzle

At the time of sowing weedicide application was done at the height of 500 mm and 550 mm measuring the discharge of nozzle in the field.

Table 4.3 Discharge rate of nozzles at height 500 mm

Height, mm	Nozzle	Discharge, l/min	Pressure, kg/cm^2	Spray width, mm
500	N1	1.80	**14**	563
	N2	1.90		565
	N3	1.89		563
	N4	1.92		564
	Average	**1.87**		**563.75**

In Table 4.3 field evaluation of weedicide applicator discharge rate and spray width of four different hollow cone nozzles were calculated at the pressure of 14 kg/cm^2 and height of 500 mm. The results indicated that and the average discharge rate of nozzles was 1.87 l/min at pressure 14 kg/cm^2 and average spray width was 563.75 mm.

Table 4.4 Discharge rate of nozzles at the height 550 mm

Height, mm	Nozzle	Discharge, l/min	Pressure, kg/cm^2	Spray width, mm
550	N1	1.88	14	568
	N2	1.89		567
	N3	1.98		565.6
	N4	1.90		567
	Average	**1.91**		**566.9**

In Table 4.4 field evaluation of weedicide applicator discharge rate and spray width of four different hollow cone nozzles calculated at the pressure of 14 kg/cm^2 and height of 550 mm. The results indicated that and the average discharge rate of nozzles was 1.91 l/min at the pressure 14 kg/cm^2 and average spray width was 566.75 mm.

Table 4.5 Spray angle of hollow cone nozzles at height 500 mm

Nozzle type	Pressure, kg/cm^2	Height, mm	Nozzle	Spray angle, Degree
Hollow cone	14	500	N1	60
		500	N2	62
		500	N3	63
		500	N4	61

In Table 4.5 laboratory evaluation of weedicide applicator spray angle for four different hollow cone nozzles calculated for pressure of 14 kg/cm^2 and height of 500 mm. The data observed and measured the spray angles of nozzles were 60,61,62,63 and degrees for N1, N4, N2 & N3 nozzles respectively.

Table 4.6 Spray angle of hollow cone nozzles at height 550 mm

Nozzle type	Pressure, kg/cm^2	Height, mm	Nozzle	Spray angle, Degree
Hollow cone	14	550	N1	60
		550	N2	62
		550	N3	63
		550	N4	61

In Table 4.6 field evaluation of weedicide applicator spray angle for four different hollow cone nozzles were measured at the pressure of 14 kg/cm^2 and height of 550 mm. The results indicated that the spray angles of the nozzles were 60, 61, 62, 63 and degrees for N1, N4, N2, and N3 hollow cone nozzles respectively.

4.3 Application of Weedicide

One litre Pendimethalin weedicide mixed with 200 liter of water was used as chemical solution. Application of weedicide on chick pea crop Rajvijay-203 at the time of sowing operation with tractor operated seed ferti drill-cum-weedicide applicator. It covered the 0.50 ha area of field.

4.4 Field Testing of Tractor Operated Seed Ferti Drill-cum-Weedicide Applicator

The developed tractor operated seed ferti drill-cum-weedicide applicator was tested at CDF workshop and field test was conducted at farms of Wani-Rambhapur. In field performance viz, field capacities, field efficiency, fuel consumption, working width, has been worked out for the feasibility of machine

4.4.1 Moisture content of soil

Moisture content of soil during field testing was measured by the rapid soil moisture meter. The average of moisture content of field was 11 percent. The minimum and maximum moisture content were 10.23 and 11.45 percent respectively.

Table 4.7 Moisture content of soil

Sr. no	Moisture content %		
	Trial I	Trial II	Trial III
1	11.20	11.32	11.01
2	10.23	10.25	11.22
3	11.44	11.45	10.92
Average	**10.95**	**11.00**	**11.05**

From the Table 4.7 it was observed that the average soil moisture content in trial I at the time of weedicide application was 10.95%. In trial II the average soil moisture level was 11.00% and in trial III it was 11.05 %

4.4.2 Bulk density of soil

The bulk density of soil was calculated by considering the weight of core cutter, the mass of core cutter + wet soil, the mass of core cutter + dry soil and volume of core cutter. The bulk density of soil was 1.101 gm/cm^3.

4.4.3 Speed of Operation

The speed was calculated by the time required for the machine to travel the distance of 20 m between two poles. Averages of such readings were taken to calculate the traveling speed of operation. The average forward speed of tractor for trial I, II & III was 3.08, 3.12 & 3.55 km/h respectively, found during the test. The average speed was found to be 3.25 km/h during the test.

Table 4.8 Speed of operation for trial I

Sr.no	Time required to travel 50 m distance, s	Time required for turning, s	Forward speed km/h
1	83	11	2.16
2	78	12	2.30
3	75	10.32	2.38
4	70.03	12.65	2.57
5	66.66	14.44	2.70
6	58.06	13.9	3.10
7	51.13	12	3.52
8	47	11.3	3.77
9	43	11.8	4.11
10	42.75	11	4.21
Average	**61.46**	**12.04**	**3.08**

In Table 4.8 speed of operation of trial I was calculated. The results indicated that average speed of operation of trial I was 3.08 km/h.

Table 4.9 Speed of operation for trial II

Sr.no	Time required to travel 50 m distance, s	Time required for turning, s	Forward speed km/h
1	78	8	2.30
2	74.4	9	2.42
3	69	10	2.60
4	64.7	11	2.78
5	60.4	10	2.98
6	58	8	3.10
7	55	7	3.22
8	47.7	9	3.77
9	44	8	4.01
10	43.7	11	4.11
Average	**59.48**	**9.2**	**3.12**

In Table 4.9 speed of operation of trial II was calculated. The results indicated that average speed of operation of trial II was 3.12 km/h

Table 4.10 Speed of operation for trial III

Sr.no	Time required to travel 50 m distance, s	Time required for turning, s	Forward speed km/h
1	72.5	9	2.48
2	65.6	11	2.74
3	61	13	2.96
4	55.5	8	3.24
5	53	12	3.41
6	49	15	3.68
7	44.7	9.5	4.02
8	42.4	13	4.24
9	41.6	8	4.32
10	40	10	4.48
Average	**52.53**	**10.85**	**3.55**

In Table 4.10 speed of operation of trial III was calculated. The results indicated that average speed of operation of trial III was 3.55 km/h

4.3.4. Draft requirement

To measure the draft required for tractor operated seed ferti drill-cum-weedicide applicator, total 5 observations were taken with load and without load conditions.

Table 4.11 Draft required with load and without load condition

Sr no.	Draft with load, kgf	Draft without load, kgf	Draft , kgf
1	580	280	300
2	570	270	300
3	610	290	320
4	597	290	307
5	615	310	315
Average	**594.4**	**288**	**306.4**

In Table 4.11 The draft of implement was measured by using digital dynamometer with load cell. The average of draft required with on load condition was found 594.4 kgf and with average of no load condition was found 288 kgf. The average draft for 45 hp tractor operated seed ferti drill-cum-weedicide applicator was found 306.4 kgf at an average speed of 3.25 km/h. Calculations are indicated in Appendix.

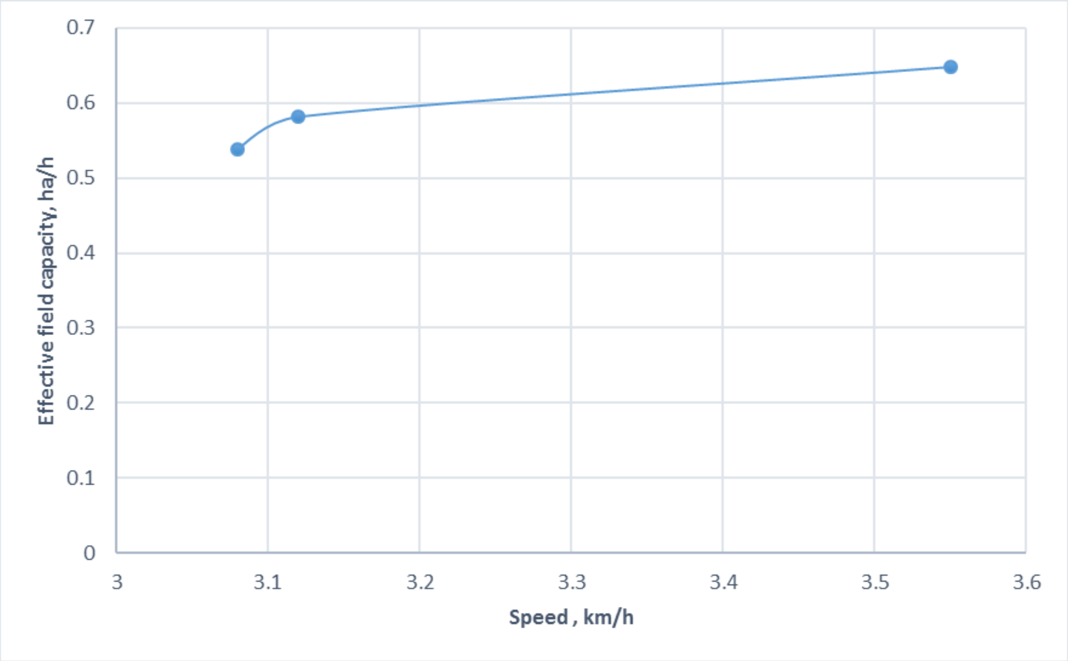

Fig. 4.1 Effective field capacity of weedicide applicator

Fig. 4.1 represents effective field capacity at various speeds. Blue line indicates effective field capacity in ha/h. The minimum value of E. F. C is 0.539 ha/h and the maximum value of EFC is 0.648 ha/h at speed of 3.08 km/h and 3.55 km/h respectively. The average value of EFC is 0.592 ha/h at average speed 3.25 km/h.

4.3.5 Depth of seed placement

The depth of placement of seed during the sowing was measured by taking randomly 10 observations. The depth of placement of chick pea seed was found to be in the range of 3.5 to 5.2 cm (average 4.24 cm) as against the recommended 4 to 5 cm depth.

 

Fig. 4.2 Before and after operation of sowing with weedicide application

4.3.6 Effective field capacity

The effective field capacity was calculated by considering the productive as well as non-productive time required during the field operation of the weedicide applicator. The effective field capacity of the tractor operated seed ferti drill-cum-weedicide applicator was found to be 0.592 ha/h at an average speed of 3.25 km/h. Calculations are given in Appendix B

4.3.7 Theoretical field capacity

Theoretical field capacity depends upon the speed of operation and theoretical width covered by the implement. The theoretical field capacity of the tractor operated seed ferti drill-cum-weedicide applicator for at an average speed of 3.25 km/h and theoretical width of 2.25 m was calculated to be 0.731 ha/h. calculations are given in Appendix B

4.3.8 Field efficiency

Field efficiency was calculated from the values of theoretical field capacity and effective field capacity. The field efficiency for the tractor operated seed ferti drill-cum-weedicide applicator was found to be 81.02%. calculations are given in Appendix B

Table 4.12 Theoretical field capacity, effective field capacity and field efficiency of machine for weedicide application (Trial-I)

SN	Speed, (km/h)	T. F. C (ha/h)	E. F. C. (ha/h)	F.E. (%)
1	2.16	0.486	0.400	82.481
2	2.30	0517	0.405	78.421
3	2.38	0.535	0.432	80.917
4	2.57	0.578	0.442	76.565
5	2.70	0.607	0.457	75.291
6	3.10	0.697	0.552	79.212
7	3.52	0.792	0.597	75.4479
8	3.77	0.848	0.657	77.499
9	4.11	0.924	0.727	78.776
10	4.21	0.947	0.721	76.171
Average	**3.08**	**0.693**	**0.539**	**78.08**

In Table 4.12 it was observed in trial I that minimum and maximum theoretical field capacity, effective field capacity, and field efficiency were 0.486, 0.400, 75.29 and 0.947, 0.721, 82.48 percent respectively. Average value of theoretical field capacity, effective field capacity, and field efficiency was 0.693, 0.539, 78.08 percent respectively.

Table 4.13 Theoretical field capacity, effective field capacity and field efficiency of machine for weedicide application (Trial-II)

SN	Speed, (km/h)	T. F. C (ha/h)	E. F. C. (ha/h)	F.E. (%)
1	2.30	0.517	0.436	84.43
2	2.42	0.544	0.471	86.75
3	2.60	0.685	0.494	84.57
4	2.78	0.625	0.514	82.36
5	2.98	0.670	0.557	83.16
6	3.10	0.697	0.589	84.57
7	3.22	0.724	0.620	85.66
8	3.77	0.848	0.689	81.27
9	4.01	0.902	0.711	78.86
10	4.11	0.924	0.745	80.72
Average	**3.12**	**0.703**	**0.582**	**83.19**

In Table 4.13 it was observed in trial I that minimum and maximum theoretical field capacity, effective field capacity, and field efficiency was 0.517, 0.436, 78.86 and 0.924, 0.745, 86.75 percent respectively. Average value of theoretical field capacity, effective field capacity, and field efficiency were 0.703, 0.582, 83.19 percent respectively.

Table 4.14 Theoretical field capacity, effective field capacity and field efficiency of machine for weedicide application (Trial-III)

SN	Speed, (km/h)	T. F. C (ha/h)	E. F. C. (ha/h)	F.E. (%)
1	2.48	0.558	0.484	86.76
2	2.74	0.616	0.523	84.92
3	2.96	0.666	0.549	82.45
4	3.24	0.729	0.623	85.57
5	3.41	0.767	0.626	81.67
6	3.68	0.828	0.646	78.14
7	4.02	0.904	0.726	80.41
8	4.24	0.954	0.753	79.00
9	4.32	0.972	0.795	81.82
10	4.36	0.981	0.759	77.42
Average	**3.55**	**0.797**	**0.648**	**81.81**

In Table 4.14 it was observed in trial I that minimum and maximum theoretical field capacity, effective field capacity, and field efficiency were 0.558, 0.436, 78.86 and 0.981, 0.759, 86.76 percent respectively. Average value of theoretical field capacity, effective field capacity, and field efficiency were 0.703, 0.582, 83.19 percent respectively.

4.3.9 Fuel consumption

The average fuel consumption of tractor operated seed ferti drill-cum-weedicide applicator using 45 hp tractor was found to be 4.52 lit/h

4.3.10 Tractor wheel slippage

The number of revolution of tractor wheel with load and without load condition was counted for a 20 m length. The average wheel slip of tractor with tractor operated seed ferti drill-cum-weedicide applicator was found to be 9.87 per cent.

Table 4.15 Tractor wheel slippage

Sr. no.	Revolution with load, N2 for 20 m	Revolution without load, N_1 for 20 m	Slip (%)
1	155	138	10.96
2	152	136	10.52
3	160	143	10.62
4	147	132	10.20
5	152	138	9.21
6	162	148	8.64
7	148	153	8.92
8	162	149	8.02
9	147	131	10.88
10	149	133	10.73
Average	**155.4**	**140.1**	**9.87**

In Table 4.15 it was observed that minimum wheel slippage and maximum wheel slippage 8.02 and 10.88 percent respectively. Average wheel slippage was 9.87 percent.

Table 4.16 Field performance results of tractor operated seed ferti drill-cum- weedicide applicator

SN	Particulars		Trial I	Trial II	Trial III	Avg. Result
1	Area covered, m^2		6072			
2	Actual operating time, min		26.02			
3	With of operation cm		45x5=225			
3	Time loss in turning, min		0.20	0.15	0.18	0.17
4	Depth of operation, cm		4.50	5.00	5.00	4.83
5	Depth of seed placement, cm		4-5			
6	Forward speed, km/h		3.08	3.12	3.55	3.25
7	Effective field capacity, ha/h		0.539	0.589	0.648	0.592
8	Theoretical field capacity, ha/h		0.693	0.703	0.797	0.731
9	Field efficiency, %		78.08	83.19	81.81	81.02
10	Draft requirement, kgf		306.4			
11	Fuel consumption, l/h		4.53	4.33	4.71	4.52
12	Wheel slippage, %		9.87			
13	Discharge rate, l/min/nozzle	Lab	1.91	1.92	1.91	
		Field	1.87	1.91	1.89	
14	Moisture content of soil, %		10.95	11	11.05	11

The weedicide applicator was tested on 0.60 ha area. The field performance of the machine was carried out at CDF Wani-Rambhapur field. The Trial was taken during sowing of chick pea crop, Rajvijay-203

4.4 Cost Economics of Tractor Operated Seed Ferti Drill-cum-Weedicide Applicator

The cost of operation per hour and per hectare of tractor operated seed ferti drill-cum-weedicide applicator was computed as per method is given in chapter III.

4.4.1 Specifications and Fabrication cost of tractor operated seed ferti drill-cum-weedicide applicator

The specifications and fabrication cost of tractor operated seed ferti drill-cum-weedicide applicator are shown in Table 4.17. The cost of complete seed drill was Rs. 39500/- which was directly purchased from the market. The other costs are as shown in Table 4.17. The total weight of the seed drill was 585 kg and the fabrication cost was Rs. 61250/-

4.4.2 Cost of operation per hour of tractor operated seed ferti drill-cum- weedicide applicator

The total cost of operation of tractor operated seed ferti drill-cum weedicide applicator per hour is the addition of cost of operation of tractor and cost of operation seed drill and weedicide applicator per hour. Cost estimation depends upon fixed costs and operating costs. Cost of operation of the tractor and seed drill and weedicide applicator including fixed and variable costs per hour is presented in Table 4.18. The fixed cost of operation of tractor was Rs.163.6 and that of seed ferti drill cum weedicide comes to Rs.37.25 The total operating cost was Rs.428.35 and Rs.16.33 respectively. Total cost of operation of seed ferti drill-cum-weedicide applicator was Rs.645.53 per hour and 1090.42 per hectare. All the calculations of cost of operation are given in Appendix-C

Table 4.17 Specifications and Fabrication cost of tractor operated seed ferti drill-cum-weedicide applicator

Sr. No.	Components	Specification	Material of construction	Quantity, No.	Cost, Rs.
1	Main frame, mm	2550x1850x450	M.S. angle	1	39500
2	Seed and fertilizer box, mm	1840x450x260	M.S. sheet	1	
3	Seed and fertilizer metering mechanism	Length -80, Diameter -50	Cast Iron.	5	
4	Ground wheel	Diameter 280, width 4mm	M.S. flat	1	
5	Power transmission unit	Chain pitch15 total length1500		1	
6	Tynes, mm	410x76x20	MS Flat	5	
7	Seed and fertilizer delivery tube	Diameter 20mm, thickness 2mm, length of tube 650mm	Transparent flexible plastic tube		
8	Soil cutting blade		High Carbon Steel	5	
9	Supporting frame of tank, mm	1600x610x580	M.S Angle	1	2500
10	Supporting frame of HDP pump, mm	Height 860 mm, width 270 mm	M.S Angle	1	800
11	Weedicide Tank, mm	Length 860,width 640,height 440	HDPE	1	1800
12	HDP Pump			1	14200
13	PTO Pulley	Dia 170 mm,	Aluminum alloy	1	500
14	Nozzle		Plastic	4	200
15	HDP Pump pulley	Dia 110 mm	Aluminum alloy	1	800
16	Weedicide Pipe			3	800
17	Nozzle frame			1	1000
18	Miscellaneous	1) Nuts, Bolts, and Washers etc.	60		850
		2) Paint	1.5 lit.		500
19	Total weight, kg.				585
20	Total machine cost, Rs.				61250/-

Table 4.18 Cost of operation per hour of tractor operated seed ferti drill- cum-weedicide applicator

SN	Particulars	Cost of operation for tractor	Cost of operation for seed ferti drill-cum-weedicide applicator
A) Fixed costs			
1	Depreciation, Rs/h	79.00	18.37
2	Interest, Rs/h	60.6	16.84
3	Insurance, Rs/h	8.00	Nil
4	Tax, Rs/h	8.00	Nil
5	Housing cost, Rs/h	8.00	2.04
	Total fixed cost, Rs/h	163.6	37.25
B) Operating costs			
1	Fuel cost, Rs/h	291.46	Nil
2	Lubricants cost, Rs/h	29.14	Nil
3	Repairs & maintenance cost, Rs/h	64.00	16.33
4	Operators (labour) wages, Rs/h	43.75	Nil
	Total variable cost, Rs/h	428.35	16.33
C) Cost of operation			
1	Total cost of operation (Rs/h) = Fixed cost + operating cost	591.95	53.58
D) Cost of operation (Rs/h)		**645.53**	
E) Cost of operation per hectare (Rs/ha)		**1090.42**	

4.4.3 Cost of operation per hour of traditional method removing weeds from field manually

The weeding operation by the use of khurpi required 300-700 man-h/day to cover 1 ha area by manually operation on field.

1.Considered, for the chick pea crop required 400 man-h/day to cover the 1 ha area.

2.working hours of man for one day is 8 h/day

For, 1 ha = 400 man-h/day

Total number of labour required to cover the 1ha field

$$= \frac{400}{8}$$

= 50 labour

38 labour required to remove the weeds from 1ha area of field of operation

Labour cost for per day is Rs.150 for weeding operation by the use of khurpi

For, Cost of operation for removing weeds per ha = 150 x 50

= 7500 Rs/ ha

Rs.150 per labour cost of weeding operation.

For Cost of operation of one labour per hour = 150/8

= Rs.18.75

For 50 labour cost of operation per hour was = 50 x 18.75

=Rs. 937.5

The cost of operation /h by traditional method is = Rs.937.5

The cost of operation/ ha is = Rs.7500

4.6 Comparison of cost of operation of tractor operated seed ferti drill-cum-weedicide applicator and traditional method removing weeds manually.

From the Table 4.19 comparison for cost of operation for tractor operated seed ferti drill-cum-weedicide applicator and cost of operation per hour of traditional method removing weeds from field manually is given. The cost of saving per hour and per hectare in tractor operated seed ferti drill-cum-weedicide applicator was 32 % and cost of saving in hectare was 85 %.

Table 4.19 Comparison of cost of operation of tractor operated seed ferti drill-cum-weedicide applicator and traditional method removing weeds manually.

Sr.no	Cost of operation for tractor operated seed ferti drill-cum-weedicide applicator		Cost of operation per hour of traditional method removing weeds from field manually		Saving (%)
1	Cost of operation Rs/h	Rs 645.53	Cost of operation Rs/h	Rs 937.50	32%
2	Cost of operation Rs/ha	Rs 1090.42	Cost of operation Rs/ha	Rs 7500	85%

From Table 4.19 it was observed that cost of operation of tractor operated seed ferti drill-cum-weedicide applicator was less than cost of operation of traditional method of the weed removing operation. Cost of operation for seed ferti cum weedicide is Rs/ha 1090.42/- and traditional method is Rs.7500/-It was clear that the development of tractor operated seed ferti drill-cum-weedicide applicator suitable and useful for weedicide application at the time of sowing operation.

CHAPETER V

SUMMARY AND CONCLUSIONS

Farm mechanization is the application of engineering technology in agricultural operation to do a job in a better way to improve productivity. This includes development, application and management of all mechanical aids for crop production, water control, material handling, storing and processing. Sustainable development in agriculture can be achieved by mechanization in agriculture. Mechanization can help in increasing the production by timely farm operations, reducing losses, reducing the cost of operations. It also ensures better management of costly inputs and enhances the productivity of natural resources. It also reduces drudgery in farm operations.

The sowing operation is one of the most important cultural practices associated with crop production. Increase in crop yield, cropping reliability, cropping frequency and crop returns all depend on the uniform and timely establishment of seed into the field. There are two broad areas in optimizing seed establishment. First, seed growers and seed merchants have a responsibility to provide quality seeds. Second, farm managers must be aware of the agronomic requirements for optimum seed establishment and be able to interpret this information in a meaningful way so as to assist with the selection, setting and management of all farm machinery, especially seed drill.

Weed is a major problem for the crop growth. This create the obstruction to the crop while the growing hence its control before the crop growing is important. There are two most important methods of weed control by the of chemicals. Pre-emergence and post emergence application of weedicide.

Pre-emergence application of the weedicide means application of weedicide before sowing of the crop. The pre-emergence weedicides are Pendimethalin, S-metolachlor. Weedicide application is an important operation of weedicide application to reduce the intensity of the weeds in field before the crop emergence. It is carried out at the stage when the moisture content in the field is available satisfactorily to the crop growth. Another method is post-emergence application of weedicide for reducing intensity of weed in the field. Post-emergence weedicide is glyphosate it is called round up more useful for control the weed and is applicable after the crop emergence

Presently farmers are using different types of implements for different farm operations as seed bed preparation, sowing, inter-culturing and spraying, etc. It is costly and difficult for small and marginal farmers to maintain number of implements. Therefore, considering above point it is decided to develop a tractor operated seed ferti drill-cum-weedicide applicator as combination tool to minimize number of implements, save number of operations, save time, labour and cost of production

Tractor operated seed ferti drill-cum-weedicide applicator was developed for carrying all operations simultaneously i.e. sowing, seed covering and application of weedicide at the time of sowing.

The objectives of this study were

1. To develop tractor operated seed ferti drill-cum-weedicide applicator.
2. To evaluate the techno-economic performance of tractor operated seed ferti drill-cum-weedicide applicator.

The performance of the newly developed implement was evaluated in the field. Field trials were carried out on 0.60 ha field. The performance tractor operated seed ferti drill-cum-weedicide applicator was evaluated by determining discharge rate of nozzles, spray angles, moisture content of the soil, bulk density of soil, draft requirement, forward speed of operation, theoretical field capacity, effective field capacity, field efficiency, wheel slippage, etc.

Tractor operated seed ferti-drill-cum-weedicide applicator was used for sowing seed and simultaneously weedicide spraying application. To evaluate its performance and to study the cost economics, accordingly, the machine with the units of main frame, tynes, furrow openers, ground wheel, drives for metering device, Weedicide Sprayer unit, Seed Covering, Supporting Frame of weedicide tank, Supporting frame of HTP pump.

The newly developed tractor operated seed ferti drill-cum-weedicide applicator was evaluated in the laboratory as well as in the field for its performance. Based on the results obtained the following conclusions are drawn:

1. The effective field capacity, theoretical field capacity was found 0.59 ha/h, 0.73 ha/h, respectively and Field efficiency of tractor operated seed ferti drill-cum-weedicide applicator was found 81.02%
2. Average speed and fuel consumption tractor operated seed ferti drill-cum-weedicide applicator was 3.25 km/hr and 4.52 lit/h
3. The average tractor wheel slippage was found 9.87%
4. The working width of machine was 2250 mm with a depth of seed 2-10 cm and only one labour is required to operate the machine and it can cover 0.60 ha/h for sowing operation.
5. Working pressure for HTP pump was 14 kg/cm^2 and the average discharge from each nozzle was 1.87 l/min and total discharge per minute was 7.51 lit/min at height of 500 mm.
6. Total draft of seed ferti drill-cum-weedicide applicator was found to be 306.4 kgf
7. Weedicide required for 0.60 ha is 1 lit of Pendimethalin. Spray angles of hollow cone nozzles at height of 500 mm were 60, 61,62,63. Spray angles of hollow cone nozzles at height of 550 mm were 60,61,62,63.
8. Moisture content and bulk density of soil was found 11 percent and 1.101 g/cm^3
9. The total cost of tractor operated seed ferti drill-cum-weedicide applicator was found Rs.61250/-
10. The total cost of operation of tractor operated seed ferti drill-cum-weedicide applicator was found Rs.645.53/-per hour and the total cost of operation of tractor operated seed ferti drill-cum-weedicide applicator was found Rs.1090.42/-per hectare

11. Cost of operation per hour and per hectare of traditional method of removing weeds from field manually was found Rs.937.5/- and Rs.7500/- respectively and the cost of saving per hour and per hectare in tractor operated seed ferti-cum-weedicide applicator was 32% and 85% respectively.

CHAPTER VI

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APPENDIX-A

Design of frame for tank for weedicide applicator

The specification of the m.s. angle frame was 1600 x 580 x 610 mm with thickness 5 mm and specification of the tank is 860 x640 x 440 mm

L = the length of the frame where tank is fitted

i.e L= 370 mm

W = 1960 N

Bending moment, M= W x L

= 1960 x 370

725.2 x 10^3 N-mm,

Hence design frame for lifting the tank is safe.

Design Supporting frame for HTP pump

Length of belt

consider,

r_1 and r_{2} ,= was radius of the pulley,

x = the distance between the two Centre of the pulley,

L= is the total length of the belt

Here, distance between the centre two pulley was 1220 mm

d_1 = 170 mm, d_2 = 110

r_1= 85mm, r_2=55 mm

Length of belt = $\frac{\pi}{2}(\mathrm{d1} + \mathrm{d2}) + 2x + \frac{(d1-d2)^2}{4x}$

$= \frac{3.14}{2}(170 + 110) + \frac{(170-110)^2}{4\times1220}$

= 1.57 (280) + .0737

= 439.6+0.737

= 440.33 mm

Diameter of pulley

The diameter of the pulley (D) may be obtained either from velocity ratio consideration or centrifugal stress consideration. We know that the centrifugal stress induced in the rim of the pulley,

$$\sigma t = \rho .\ V^2$$

where,

ρ = Density of the rim material

= 7200 kg/m3 for cast iron

v = Velocity of the rim = πDN / 60, D being the diameter of pulley and

N is speed of the pulley.

For cast iron pulley centrifugal stress was 4.5 MPa = 4.5×10^6 N/m^2 4.5 N/mm^2

$$\sigma t = \rho .\ V^2$$

$$4.5 \times 10^6 \ N/m^2 = 7200 \times V^2$$

Velocity of the rim was 25 m/s

i.e. V= 25 m/s

velocity of rim = $\frac{\pi\ D\ N}{60}$

$$25 = \frac{\pi \times D \times 540}{60}$$

=150 mm

Therefore, Diameter of the pulley 150 mm

APPENDIX-B

Sample Calculation of Theoretical field capacity, Field Capacities and Field Efficiency of tractor operated seed ferti drill-cum-weedicide applicator.

a) Theoretical field capacity (TFC) of weedicide applicator was calculated under various increasing speed of operation.

$$T.F.C = \frac{S \times W}{10}$$

Where,

T.F.C. = theoretical field capacity, ha/hr

W = theoretical width of Implement = 2.25 m

S = speed of operation = 3.25 km/h

$$= \frac{3.25 \ x\ 2.25}{10}$$

= 0.731 ha/h

b) Effective or actual field capacity of weedicide applicator was calculated under various increasing speed of operation

At speed 3.25 km/h

$$E.F.C = \frac{A}{T_P + T_1}$$

Where,

E.F.C. = effective field capacity, ha/h

A = area = 0.60 ha

T_p = productive time = 0.433 h

T_1 = non-productive time, (Time loss for turning) = 0.0028 hr

T_t = Total time required to cover 0.50 ha is = 0.433 hr

$$= \frac{0.0036}{0.0216}$$

= 0.592 ha/h

c) Field Efficiency of tractor operated seed ferti drill-cum-weedicide applicator

The field efficiency of machine was calculated on the basis of various speed of operations.

$$FE = \frac{EFC}{TFC} x100$$

Where,

E.F.C. = effective field capacity = 0.592 ha/h

T.F.C. = theoretical field capacity = 0.731 ha/h

Field efficiency = $\frac{0.592}{0.731}$ ×100 = 80.98%

Remaining all calculation for various speeds of operation are same as above.

APPENDIX-C

Cost of operation per hour and per hectare for tractor operated seed ferti drill-cum-weedicide applicator.

I. Determination of cost of operation per hour for tractor

A. Fixed cost per hour

1) Depreciation per hour

Here,

Purchase price (P) = Rs. 8,00,000.00/-

Total life of tractor and implement (L) = 10 years

No. of working hours of the tractor and implement per year, (h) = 1000 h

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

$$= \frac{800000 - (10/100) \times 800000}{10 \times 1000}$$

D = Rs 79

2) Interest per hour

Here, R = 15%, S = 0.1 × P

R=Rate of interest per year

S= Salvage value

P= Purchase price

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

$$= \frac{800000 + (10/100) \times 800000}{2} \times \frac{15}{100 \times 1000}$$

I = Rs. 60.6

3) Housing cost per hour

1% of purchase price

$$I = \frac{P}{h} \times \frac{1}{100}$$

$$= \frac{800000 \times 1}{1000 \times 100}$$

H = Rs. 8

4) Insurance cost per hour

1% of purchase price = Rs. 8

5) **Taxes cost per hour**

1% of purchase price = Rs. 8

Total fixed cost = 79 + 60.6 + 8 + 8 + 8 = Rs.163.3

B. Operating cost per hour

1) **Fuel cost =** 4.5 x 64.77 = Rs.291.46

2) **Lubricants cost**

10% of fuel cost = 291.46 x 10/100 =Rs.7.38

3) **Repair and maintenance cost per hour**

It is taken as 8% of purchase value

$$\text{Repair \& Maintenance} = \frac{8 \text{ x P}}{100 \text{ x h}}$$

$$= \frac{8 \text{ x } 800000}{100 \text{ x } 1000}$$

= Rs.64

4) **Wages of operator per hour**

= Rs.350/day of 8 hour

= 350/8

= Rs.43.75

Total operating cost = 291.46 + 29.14 + 64+ 43.75 = Rs. 428.35

Total cost of operation of tractor per hour

= Fixed cost (Rs/h) + Operating cost (Rs/h)

= 163.6 + 428.35

= Rs.591.95

II. Determination of cost of operation per hour for seed ferti-drill-weedicide applicator

A. Fixed cost per hour

1) **Depreciation per hour**

Here,

P = Rs.61250

L = 10 years

h = 300 h

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

$$= \frac{61250 - (10/100) \times 61250}{10 \times 300}$$

D = Rs.18.37

2) **Interest per hour**

Here, R = 15%, S = 0.1 × P

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

$$= \frac{61250 + (10/100) \times 61250}{2} \times \frac{15}{100 \times 300}$$

I = Rs.16.84

3) **Housing cost per hour**

1% of purchase price

$$I = \frac{P}{h} \times \frac{1}{100}$$

$$= \frac{61250 \times 1}{300 \times 100}$$

H = Rs. 2.04

4) **Insurance cost per hour - NIL**

5) **Taxes cost per hour - NIL**

Total fixed cost = 18.37+ 16.84 + 2.04 = Rs. 37.25

B. Operating cost per hour

1) **Fuel cost = NIL**

2) **Lubricants cost = NIL**

3) **Repair and maintenance cost per hour**

It is taken as 8% of purchase value

$$R\&M = \frac{8 \times P}{100 \times h}$$

$$= \frac{8 \times 61250}{300 \times 100}$$

= Rs. 16.33

4) **Wages of operator per hour = NIL**

Total operating cost = 16.33

Total cost of operation of implement per hour

= Fixed cost (Rs/h) + Operating cost (Rs/h)

= 37.25 + 16.33

= Rs.53.58

Total cost of operation of tractor operated seed ferti drill-cum-weedicide applicator per hour

=Total cost of operation of tractor per hour + Total cost of operation of Implement per hour

= 591.95 + 53.58

= Rs. 645.53

III. Determination of cost of operation per hectare

$$\text{Cost of operation, (Rs/h)} = \frac{\text{Cost of operation of implement, (Rs/ha)}}{\text{Effective field capacity of implement, (ha/h)}}$$

$$= \frac{645.53}{0.592}$$

= Rs.1090.42

Total cost of operation tractor operated seed ferti drill-cum-weedicide applicator per hectare

= Rs.1090.42

VITA

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Date: / /2019 **(Ghadge Amol Sukhdeo)**