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Development of Three Row Animal Drawn Multi Crop Planter Cum Herbicide Applicator

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A B S T R A C T

Farm mechanization is a process which helps in increasing the production by timely farm operation, reducing losses and reducing the cost of operations. Man power and animal power are the major sources of farm power for small and marginal farmers in India. In this study an implement was developed to perform the operations of planting of seeds and application of herbicide simultaneously in order to aid small and marginal farmers to save money and time. It consists of a main frame, seed hoppers, seed metering devices, seed delivery tubes, inverted 'T' type furrow openers, sprayers, boom, nozzles, ground wheel, ground wheel lifting mechanism and handle. The developed implement was fabricated with the materials which are available locally at cheap cost. Fabrication cost of the implement was kept at minimum. The average field capacity and mean field efficiency was 0.121 ha/h and 70.70 per cent respectively. The average discharge of boom was 965.2 ml/min at an average pressure of 254.97 kPa. The average cost of operation was determined as Rs. 650 per ha.

Introduction

Sustainable development can be achieved by use of mechanization in agriculture. Farm mechanization helps in increasing the production by timely farm operation, reducing losses and reducing the cost of operations. It should benefit all the farmers irrespective of the size of their land holdings. Farm mechanization is primarily focused on farmers with medium and large size land holdings as they are benefitted with different types of agricultural machines which are inoperable and uneconomical to farmers with small and marginal land holdings. In India, small and marginal land holdings constitute a large portion of total land holdings. Agricultural productivity depends on availability of farm power sources. Main farm power sources for small and marginal farmers are man power and animal power. Animal power is provided by draught animals and is called as draught animal power. Design and development of farm implements are carried are considering these sources of power for small and marginal farmers.

A study was conducted by Kawade *et al.,* in which a three row multi crop bullock drawn planter was tested and the field capacity of the planter was found to be 2 ha/day with an average field efficiency of 75 per cent. The planter saved 9-27 per cent seed and 63-75 per cent labour work. A single row tillage cum multi crop planter was developed by Abebe (2018) mainly for sorghum and maize crops and strip tillage practice. Field efficiencies of planter was found out to be 77.47 per cent for maize trail and 76.52 per cent for sorghum trail. Dhruwe *et al.,* (2018) developed a five row animal drawn multi crop planter and its performance was evaluated through lab tests and field trials. The mean field capacity was 0.22 ha/h with 79.78 per cent field efficiency. Ghosal and Pradhan (2012) modified the design of cups in cup feed metering seed drill for seed pattern characteristics study of black gram seeds. Dimensions of cup i.e. 6 mm x 2.89 mm was found to be best and was used successfully up to a peripheral speed of 18.84 m/min. Overall efficiency was found to be 79.94 per cent. They conducted a similar study for green gram and the filed efficiency of seed drill was found to be 78.75 per cent (Ghosal and Pradhan, 2013).

A study conducted by Verma *et al.,* (2007) tested and compared shoe type furrow opener, shove type furrow opener and inverted 'T' type furrow opener on the basis of draft requirement, soil disturbance and seed emergence. The lowest draft of 32.12 kgf was required by inverted 'T' type furrow opener. Waghmare (2017) developed a bullock drawn multipurpose tool carrier for sowing, fertilizer application and herbicide application simultaneously. Draft requirement was 62 kg and average discharge of boom was 783.95 ml/min at 2.10 kg/cm^2 pressure.

A machine that performs multiple operations at the same time and which can be used for different crops saves time, money and labour. Planting and plant protection are some of the most important agricultural operations. A three row animal drawn multi crop planter cum herbicide applicator fulfills the requirement of performing two different operations i.e. planting and herbicide application simultaneously.

Materials and Methods

This study was conducted in the year 2018 at Department of Farm Machinery and Power Engineering, Swami Vivekananda College of Agricultural Engineering & Technology and Research Station, IGKV, Raipur. The main components are frame, furrow opener, ground wheel, power transmission system, hopper, seed metering mechanism, seed delivery tubes, hitching system, hand and beam, sprayer, sprayer boom and sprayer nozzles.

Main frame

A square shaped pipe of mild steel of size 50 x 50 x 5 mm was used for the frame. The length of the frame was kept 1675 mm in order to accommodate 3 furrow openers with the recommended spacing of crops to be cultivated and to have a desirable turning radius along with two sprayers placed on the either ends.

Furrow openers

Three inverted 'T' type furrow openers were developed. MS flat of 100 × 95 mm was drilled with four holes and welded to the tyne for clamping purpose. The total height of tyne of furrow opener was 497 mm and width was 290 mm. An extension was provided on the top of the furrow opener with two holes to mount the hopper with the help of nuts and bolts and could be adjusted to obtain desired furrow spacing as per crop requirements. Point of share was made of carbon steel with

carbon content of 0.5 per cent and thickness of 10 mm. The tyne was made of mild steel flat of width 40 mm and thickness 10 mm

Ground wheel

A ground wheel of diameter 470 mm was constructed by using 25x4 mm MS flat of 117 cm and bending it to a circle. 10 pegs of 50 mm length were made of same material and welded at uniform distances. The diameter of 470 mm was selected for the ground wheel considering the speed of operation as 1.75 km/h

Power transmission system

The power transmission system was designed to provide power to the seed metering devices and crank mechanism for sprayers from the ground wheel. Chain and sprockets were used for the power transmission system. Provisions were made so that the sprockets can be changed easily to change the speed ratio for achieving different seed rates for different crops. Power from ground wheel was transmitted to main shaft through an intermediate shaft.

Main shaft simultaneously powered both seed metering mechanism and inline slider crank mechanism which operated the sprayer pistons. With the speed of ground wheel of 19.75 rpm speed ratio of 2.03 the speeds of shaft driving seed metering mechanism was obtained as 39.7 rpm and for the inline slider crank mechanism, speed of the shaft was 25.28 rpm with 1.28 speed ratio.

Hopper

Seed hopper consisted of seed box, circular plate with cells, metering shaft and seed tube mounting pipe. A readymade hopper made of PVC with angle of repose of 30.95° was used.

Seed metering mechanism

Cell feed metering mechanism was used to meter the seeds. The rate of seed delivery depends upon the size and number of cells or hubs present in the rotor and the speed ratio of metering shaft and ground wheel shaft. Readymade standard vertical cell rotors of 5 different types were tested to meter the selected seeds. These rotors were design for specific crop as different crops have different seed density, seed spacing, shapes and size.

Seed delivery tube

PVC tube of 46.5 mm outer diameter and 280 mm length were used for passing of seeds from the seed metering devices to the boot of the furrow opener.

Hitching system

The hitch was made up of two mild steel flat of 350 x 40 mm with a distance of 70 mm in-between the flats. It was fabricated by taking two MS flats of length 350 mm on which a flat of length 125 mm was welded at an angle 68° at front end and at the rear end it was welded to the frame. Holes of 10mm were drilled at different position in the hitch to facilitate the adjustment of beam height. A beam was used to attach hitch of the implement to the yoke.

Handle

The handle was provided in the implement to control and maneuver the developed implement easily during operation. The handle was made up of MS square pipe of 25mm sides. It was made by welding three different lengths (130 mm, 380 mm and 55mm) of MS square together at a suitable angle forming a single unit. The height of handle was decided considering the ergonomic aspect of the operator.

Sprayer

Lever operated knapsack sprayers of 16 liters capacity were used. The sprayers were dismantled and the function of lever was replaced by crank mechanism to operate the sprayers.

Sprayer boom

Sprayer boom was made of 4 hose pipes of standard size which are available easily in the market. These hose pipes were connected with 3 T pipe joints in such a way that the 2 ends of the T pipe joints were connected to the hose pipes and the bottom end was fitted with sprayer nozzle. The either ends of the boom were connected to the piston of both sprayers.

Sprayer nozzle

Flat fan type nozzles made of PVC were used as per the spraying requirements. The use of other types of nozzles was not practical with the present planter cum sprayer.

Performance evaluation

The developed machine was tested in laboratory and in field as per the standard procedure by using IS 6316: 1993 and IS 10134: 1994 test codes. The developed implement was evaluated on the basis of parameters such as seed rate, nozzle discharge rate, pressure developed in sprayer boom, speed of operation, field capacity, field efficiency, draft requirement, power requirement and cost of operation. The implement was tested and evaluated for seeding of maize under controlled lab conditions. Field tests were carried out in an area of 21×19 m^2. The different component of the three row multi crop planter cum herbicide applicator were fabricated and assembled in the college workshop. The specifications of the developed implement are depicted systematically in Table 1 and isometric view of developed machine is shown in Fig. 1.

Results and Discussion

The developed sprayer cum planter was tested in the research field of SVCAET&RS, IGKV Raipur (C.G.). Missing and multiple indices were calculated for the seed spacing of 150 mm for maize crop. Missing index and multiple index was found 10.2 per cent 11.8 per cent respectively (Table 4). The pressure was recorded from the pressure gauge at five different instances. The average pressure value recorded was 254.97 kPa (Table 3).

The obtained seed rate during laboratory test was found 42.86 kg/ha for maize which was closer to the recommended seed rate. Mechanical damage to the seeds by metering mechanism was recorded through visual observation. The damage percentage of seeds was found 0.64 per cent. The damage percentage was less than 1% significance for selected crop.

Discharge rate from three flat fan nozzles was measured in ml/min at the pressure 254.97 kPa. The discharge rates were found out to be 321.8 ml/min, 313.8 ml/min and 329.6 ml/min for nozzles N_1, N_2 and N_3 respectively (Table 2). The total discharge rate of boom was 965.2 ml/min.

Machine performance results of developed machine are presented in Table 4. The average draft of the implement was found out to be 443 N. The actual field capacity was found out to be 0.121 ha/ h. Time required to cover 1 ha area was observed as 8.26 h/ha. Herbicide application was also carried out simultaneously. Field efficiency of the machine was determined as 70.7%.

Table.1 Specification of a three row animal drawn multi crop planter cum herbicide applicator

S. N.	Particulars	Specifications
1.	Name	Three row animal drawn multi crop planter cum herbicide applicator
2.	Size (length x breadth x height)	1710 mm x 1070 mm x 1160 mm
3.	Depth of sowing (mm)	Adjustable
4.	Row to row spacing (mm)	225, 300, 400 and 450
5.	Working width (mm)	1350
6.	Furrow opener	Inverted 'T' type
7.	No. of furrow openers	3
8.	Type of metering device	Cell feed metering device
9.	Ground wheel diameter (mm)	470
10.	No. of nozzles	3
11.	Average boom pressure, kPa	254.97
12.	Nozzle spacing, mm	225 to 450
13.	Nozzle height, mm	350 to 550
14.	Spray angle, °	60
15.	Power transmission	Chain and sprocket system, inline slider crank mechanism
16.	Source of power	Pair of draught animal
17.	Weight (kg)	70
18.	Labour requirement	1

Table.2 Discharge rate of nozzles

Trial	Nozzle discharge rate, ml/min			Discharge rate of sprayer boom, ml/min
	N_1	N_2	N_3	
1	314	304	322	940
2	319	306	327	952
3	322	315	331	968
4	325	319	332	986
5	329	325	336	990
Average	321.8	313.8	329.6	965.2

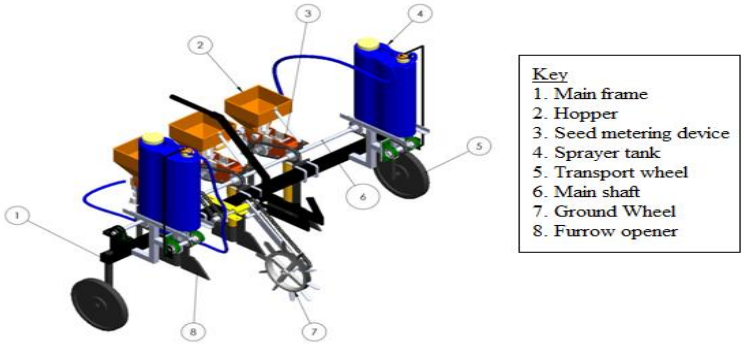
Table.3 Test results of sprayer related parameters

Particular	Observation
Average pressure developed in boom, kPa	254.97
Spray angle, °	60
Average discharge of boom, ml/min	965.2

Table.4 Machine performance result of developed multicrop planter cum applicator

S. N.	Parameters	Result
1.	Missing Index, %	10.2
2.	Multiple Index, %	11.8
3.	Depth of operation, mm	44.67
4.	Pressure in boom, kg/cm^2	2.6
5.	Speed of operation. Km/h	1.82
6.	Draught, N	444
7.	Power output, kW	0.22
8.	Theoretical field capacity, ha/h	0.171
9.	Actual field capacity, ha/h	0.121
10.	Time required to cover 1 ha, h/ha	8.26
11.	Field efficiency, %	70.70
12.	Cost of operation, Rs./ha	650
13.	Operational energy, MJ/ha	117.81

Fig.1 Isometric view of developed three row animal drawn multi crop planter cum herbicide applicator



The estimated cost of implement including material cost and fabrication cost was estimated as Rs. 15000. The cost of sowing operation per hectare was calculated Rs. 650/ha for seeding maize crop with developed machine. Operational energy of the developed machine was determined as 117.81 MJ/ha for seeding operation of maize.

In conclusion the three row animal drawn multi crop planter was designed and fabricated with the materials which are available locally at cheap cost. The machine developed was light in weight. The developed implement was subjected to laboratory tests and field tests and its performance was found to be satisfactory. The developed implement was rigid and sturdy and performed the operations of planting and herbicide application simultaneously without any issue. The average draft requirement was within the pulling capacity of medium size bullocks of this region. The average seed rates obtained were close to the recommended seed rates.

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