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Development and Performance Evaluation of Animal Drawn Maize Ridger

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Abstract:- **Maize is the third world's most important cereal after Rice and Wheat which plays a major role in Indian economy. Ridging of maize crop 30 DAS is a very important operation and maize ridging is conventionally done by manually which involves extensive labors compared to other operations, this result in higher cost of cultivation and required higher drudgery. The crop, machine and operational parameters were identified and selected and the animal drawn maize ridger was developed and evaluated for its performance in actual field conditions. The ridge dimensions were optimized top width, bottom width and ridge height (9.14cm, 16.72cm, 43.5cm) with total volume of soil cover 425.37cm^3 considering plant height and row to row spacing. The average draft of the ridger 69.81 kg-f was observed during ridging operation. The field capacity of the maize ridger was 0.06ha/h with field efficiency of 74.46 per cent. The cost of operation of maize ridger for ridging maize was found to be 1737.79 Rs/ha.**

Key word: Maize, ridger, ridging technology.

INTRODUCTION:

Maize is the third world's most important cereal after rice and wheat. Among the cereal crops in India, Maize with annual production of around 22.5 million tonnes from 8.67 million hectares ranks third in production and contributes to 2.4% of world production with almost 5% share in world harvested area in 2013-14.

Major sources of farm power include both animate (humans and draught animals) as well as inanimate sources such as diesel engines, tractors and electric motors. Bullock is one of the cheapest and oldest sources of draught power for all types of agricultural operation. Bullocks are mainly used for tillage and sowing operations. Though the population of draught animal is declining but still more than 50 percent net sown area is cultivated by animal power source. Chhattisgarh state of India, which has a large cultivable area, good natural resources, also has very large cattle population. These animals are small to medium size (250 to 450 kg) with a draughtability of 10 to 12 percent of their body weight (AICRP on UAE Report 2008). Most of the marginal and small farmers in this region depend on animal power for farm operations like tillage, sowing and threshing operations.

Khan *et al.* (2010) , Thakur *et al.* (2003), Memon *et al*. (2011), Ranawat *et al.* worked on maize tillage management and improves the crop condition as well as yield. **S**owing on ridge may provide better condition for aeration and also require less irrigation water. Labor scarcity delays these agricultural operations which has adverse effects on crop production. Therefore, there is a need to, mechanize the ridging operation of maize and other crops which will result in saving of time, money and labor. Thomas and Kaspar (1997) reported that improved understanding of maize (*Zea mays* L.) nodal root response to soil ridging is needed to allow farmers to maximize the benefits of ridge tillage systems. Birkas *et al.* (1998) were carried out study in order to determine the effect of traditional and ridge tillage systems on soil status, yield and weed cover for three years. Ahmad *et al*. (2000) were conducted a field study pertaining to different inter-tillage practices on maize. Ridging of maize crop is an essential operation 30 DAS. This prevents the plant from lodging with better stand ability. Moreover, it also provides anchorage of the lower whorls of adventitious roots above the soil level which then function as absorbing roots. Ridging improves yield but is labor intensive and it is done by hand with a hoe, spade etc. by farmers.

MATERIALS AND METHODS:

The maize ridger were designed and developed in AUTO-CAD and fabricated in the workshop of NAE, FMPE, IGKV, Raipur. The maize ridger was designed to accommodate adjustable spacing between two furrow openers varying from 31.5 to 5cm for the maize crop.

Designs requiring machining processes were generally avoided so as to make the technology accessible to rural artisans and manufacturers, who normally do not have expensive machinery such as lathes and milling machines. No alloy steels were used, but mild steel, which is locally available were used for fabrication of the various parts of implement. Unnecessary weight, which leads to added strain for the draught animals as well as for the user controlling the implement, was avoided. Enough clearance provided to allow proper ridging, and weeding with already established crops up to knee height. Adjustments were limited to the practical ones so as to keep the design as simple as possible and easy to use. Designs and technologies associated with high tooling costs, in particular machining, were avoided in order to keep the cost of production. In addition, the bolt sizes chosen were generally the same as those used on the animal drawn mould-board plough so as to avoid the acquisition of extra spanners.

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The landside Fig.3.4 was made of MS plate iron of 5 mm thickness. The landside acts as one side of the wedge, which is formed with the share. It is a long flat metal piece welded to the edge of the frog. It helps to absorb side force caused when furrow slice is turned.

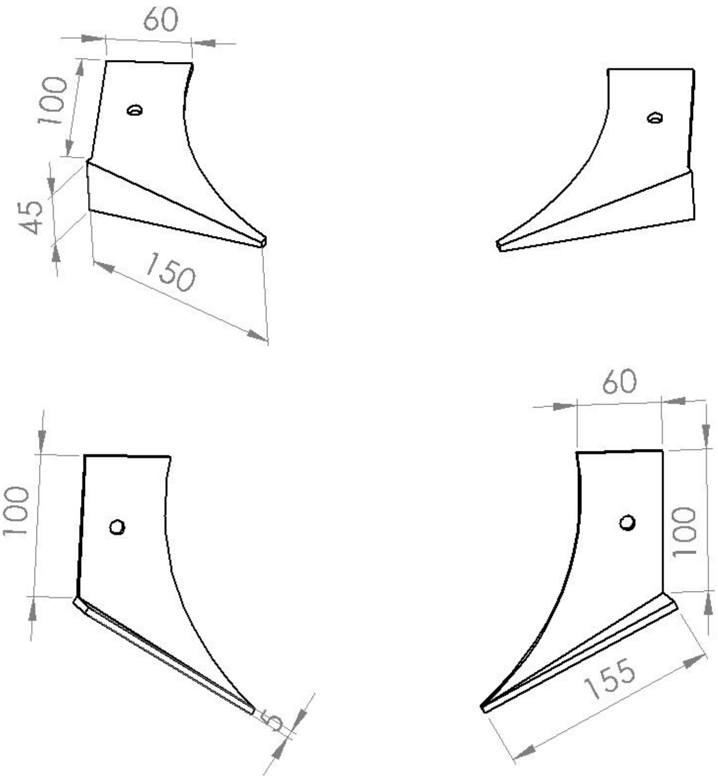

Fig1 Share of the maize ridger

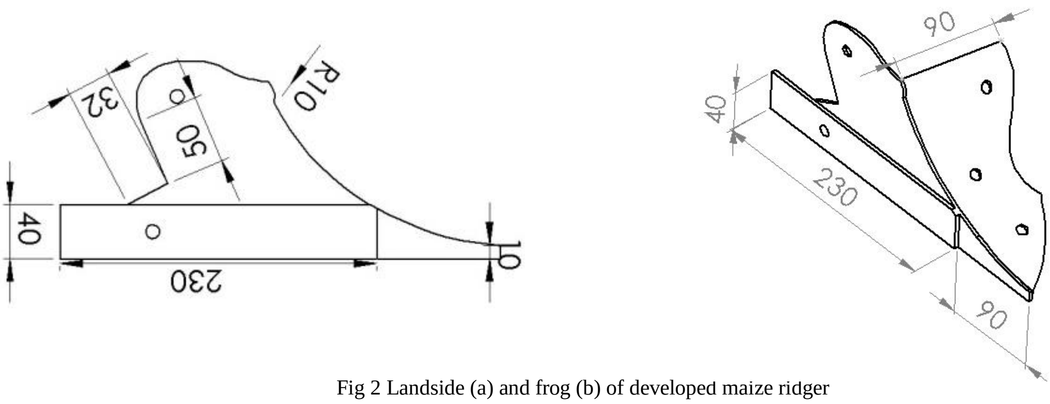

Fig 2 Landside (a) and frog (b) of developed maize ridger

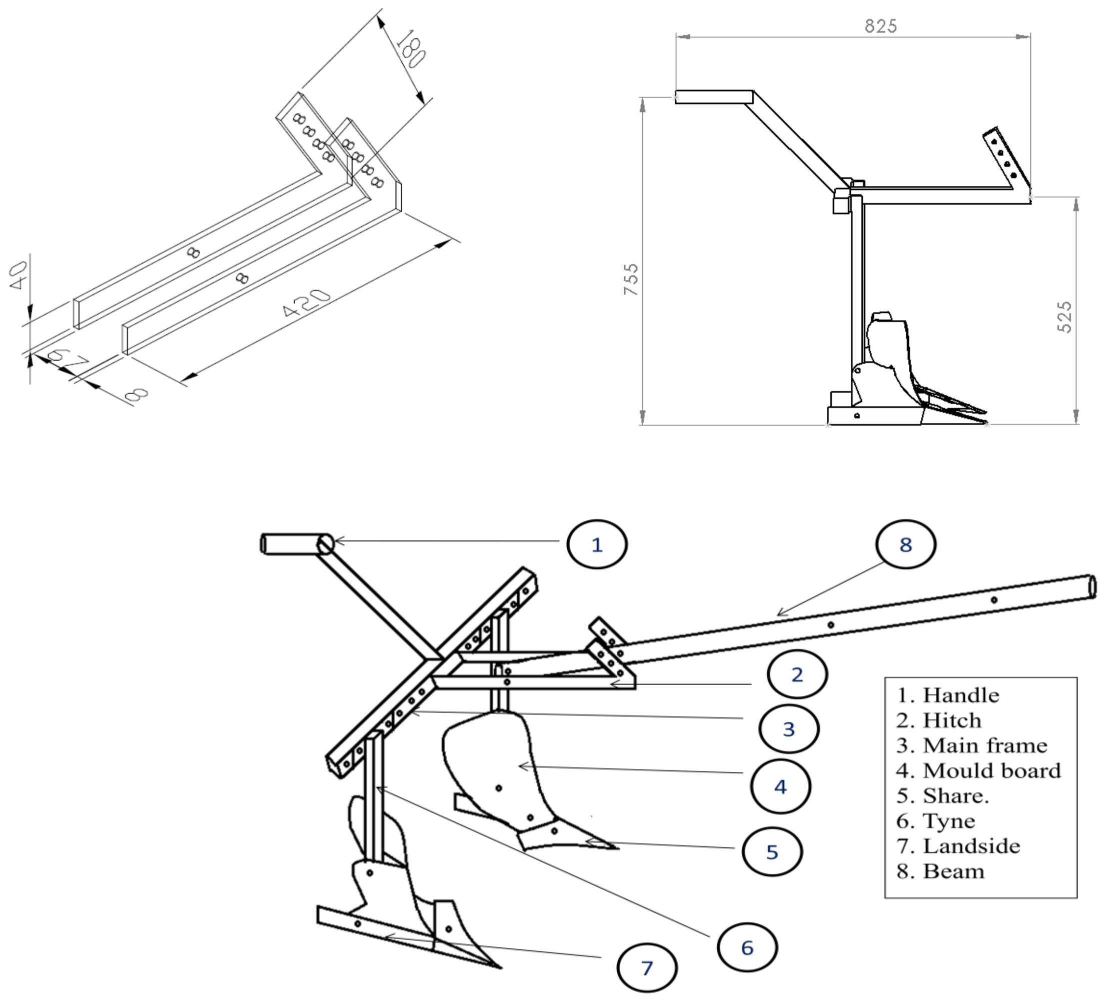

Fig 3 (a) Hitch point(b) Side view (c) Orthographic view of developed maize ridger

The plant height and row spacing were affected the performance of ridging operation which were considered for the design of the maize ridger. The unit was designed to ridging single rows of maize crop with adjustable spacing between two furrow openers (31.5 to 51cm). The machine offers the apparent advantage of timely ridging, weeding, saving of time, and labor costs and therefore, helps reducing the cost of production besides reducing the drudgery of the task. Considering the factors discussed above, an animal drawn maize ridger was developed with a set of functional components including Main frame, share, mould-board and landside-frog assembly. Ridges and furrows can be effectively formed by using animal drawn ridgers. The soil thrown by the wings of the ridgers covers the root and stem zone of the plants. Two opposite mould board bottoms were selected for the formation of ridger. The CAD view of the machine is shown in Figure 1 for ease of understanding.

Fig4 Testing of animal drawn maize ridger

Fig.5 (a) No. of weeds before ridging and (b) No. of weeds after ridging

EXPERIMENTAL DETAILS

The field performance tests were carried out to obtain actual data on overall implement performance and work capacity in the field. The field trials of animal drawn implements were conducted in the field of I.G.K.V., Raipur, which is situated at the southeastern part of Chhattisgarh and lies between $21^0$16'N latitude and $81^0$36' E longitudes with an altitude of 298m above the mean sea level. The soil of the experimental field was clay loam in texture. The average initial bulk density and moisture content were observed as 1.85 t/m^3 and 14.98% (db), respectively, for the depth of 0-150 mm.

RESULTS AND DISCUSSION:

The designed and fabricated maize ridger was tested in the laboratory as well as in the actual field condition for maize crop, to examine the performance of maize ridger. During the field trial proper spacing between two furrows openers to obtain proper ridge dimensions with minimum plant damage through the implement were optimized. During field trail it was observed that higher ridge dimension having width (16.88cm) and height (43.50cm) was obtained with T3 (inclined mould-board with 44.50 cm spacing between two furrow openers). The dimension of the ridge at various spacing and with different treatments were measured during field trial and presented in Table 1.

The field test of developed ridger was carried out at an average plant height of 35.54 cm. The average moisture content at 2.5 to 20 cm depth was 16.69 % at dry basis, 14.30 % at wet basis and the bulk density during trail was found to be 1.85t/m^3. The height of plant of maize crop, moisture content, and bulk density of soil during ridging operation is presented in Table 2.

Table1.Width, height and volume of soil handled by the ridger

Parameter	Width, cm	Height, cm	Volume handled, cm^3
S1=31.50	30.75	17.63	347.54
S2=38.00	36.42	16.88	393.88
S3=44.50	43.50	16.88	482.48
S4=51.00	49.92	15.50	477.60
Mean	40.15	16.72	425.37

Table2. Plant height, moisture content and bulk density of soil during testing

S .No.	Plant height, cm	Moisture content, % wb*	Moisture content, % db**	Bulk density, t/m^3
Range	34-38	13- 15.25	16.69	1.79-1.91
Mean	35.54	14.3	14.98	1.85
SD	25.70	32.42	7.18	0.043

*wb = wet basis, **db = dry basis

The maximum theoretical field capacity was observed with S4–51cm (0.09 ha/h) followed by S3–44.5 cm (0.08 ha/h), S2–38 cm (0.07 ha/h) and S1–31.5 (0.05 ha/h) cm respectively. It was also observed that variation in effective field capacity of the developed ridger during field test with respect to different spacing. The maximum effective field capacity was observed with S4–51cm (0.06 ha/h) followed by S3–44.5 cm (0.060 ha/h), S2-38 cm (0.051 ha/h) and S1–31.5 (0.042 ha/h) cm respectively. The detailed data were shown in Table 3.

The performance of the developed implement was compared with other method of ridging. For the comparisons the following implements were used, T1 (Tendua plough), T2 (MB plough), T3 (developed maize ridger) and T4 (Ridger plough).

Table3. Field capacity and field efficiency of developed ridger

Parameters	EFC=effective field capacity	TFC=theoretical field capacity	FE=field efficiency
S1=31.50	0.04	0.05	72.49
S2=38.00	0.05	0.07	73.78
S3=44.50	0.06	0.08	74.46
S4=51.00	0.07	0.09	74.74
Mean	0.05	0.07	73.87

Note-S1 to S4= Spacing in, cm

From the test result it was observed that the highest ridge dimension i.e. (Bottom width, top width and ridge height in cm) were obtained by the T4 - ridger plough (55cm, 5.75cm and 16.25cm) followed T3 - developed maize ridger (43.75cm, 12.75cm and 16cm), T2 - MB plough (41.75cm, 15cm and 10.75cm) and T1 - Tendua plough (59.93cm, 53cm and 2.63cm). The highest volume of soil handled was observed with T4 - ridger plough (492.38 cm^3) followed by T3 – developed maize ridger (452.31cm^3), T2 – MB plough (305.38cm^3) and T1 – Tendua plough (148.36cm^3) detail were shown in table 4.

The plant damage was observed minimum with T1-Tendua plough (1.21%) followed by T3- developed maize ridger (2.02%), T2- MB plough (10.48%) and higher plant damage was observed with T4- ridger plough (27.42%). The plant damage with Tendua plough and developed maize ridger was at par. The maximum weeding efficiency was observed with T4- ridger plough (68.25%) followed by T2- MB plough (59.25%), T3- developed maize ridger (51.50%) and lowest weeding efficiency was observed with T1- Tendua plough (13%). The weeding efficiency of ridger plough, MB plough and developed maize were found at par.

It was observed that from the table 5. The maximum theoretical field capacity were obtained with T3- developed maize ridger (0.0733 ha/h) and lowest theoretical field capacity were observed with T2- MB plough (0.0287ha/h). The effective field capacity in (ha/h) of T1- Tendua plough, T2- MB plough, T3- developed maize ridger and T4- ridger plough were 0.0395, 0.0158, 0.0548, and 0.0360 respectively. The highest field efficiency was observed with T3- developed maize ridger (74.62%), followed by T1- Tendua plough (73.68%), T2- MB plough (54.65%) and lowest field efficiency observed with T4- ridger plough (51.62%). The highest draft were observed with T4- ridger plough (76.75kg-f) followed by T2- MB plough (72.25kg-f), T3- developed maize ridger (69.50kg-f) and lowest draft was observed with T1- Tendua plough (32.25 ha/h). The speed of operation during field operation with various implement were found T1- Tendua plough (1.86kmph),T2- MB plough (1.44),T3- developed maize ridger (1.73kmph) and T4- ridger plough (1.30kmph).

Table4. Effect of different ridging technology on ridge dimension and volume of soil cut.

Parameters/ Treatments	Dimension of ridge			Volume, cm^3
	Bottom width, cm	Top width, cm	Height, cm	
T1: Tendua Plough	59.93	53.00	2.63	148.36
T2: MB plough	41.75	15.00	10.75	305.38
T3: Maize ridger (dev.)	43.75	12.75	16.00	452.31*
T4: Ridger plough	55.00	5.75	16.25	492.38*
SEm	0.468	0.692	1.140	34.871
CD at 5%	1.496	2.214	3.646	111.552
CV	1.867	6.402	19.985	19.949

Table 5. Effect of different ridging technology on speed, draft, TFC, EFC, FE plant damage and weeding efficiency

Parameters/ Treatments	Speed (km/h)	Draft (kg f)	TFC (ha/h)	EFC (ha/h)	FE (%)	Plant Damage (%)	Weeding efficiency (%)
T1	1.86	32.25	0.0537	0.0395	73.68 [a]	1.21*	13.00
T2	1.44	72.25	0.0287	0.0158	54.65[b]	10.48	59.25
T3	1.73	69.50	0.0733	0.0548	74.62[a]	2.02*	51.50
T4	1.30	76.75	0.0698	0.0360	51.62[b]	27.42	68.25
SEm	0.043	1.231	0.002	0.002	2.237	0.902	1.900
CD at 5%	0.136	3.938	0.006	0.006	7.156	2.884	6.079
CV	5.387	3.928	6.410	10.128	7.030	17.538	7.918

T1 (Tendua plough), T2 (MB plough), T3 (developed maize ridger) and T4 (Ridger plough)

Table 6. Shows the cost of ridging operation was minimum with developed maize ridger (1737.79 Rs/ha) followed by Tendua plough (2652.82 Rs/ha), Ridger plough (3000 Rs/ha) and maximum cost of operation was observed with MB plough (6440 Rs/ha).

Table 6. Cost calculation of different ridging technology used in maize field

S. No.	Particular	Maize ridger	Ridger plough	Tendua plough	MB plough
1.	Cost of machine, `	2960.00	7500.00	2400.00	2850.00
2.	Life of the machine (y)	5	10	5	10
3.	Annual use (h)	240	240	240	240
4.	Depreciation, `/h @10%	532.80	675.00	432.00	256.50
5.	Interest, `/h@12%	195.36	495.00	158.40	188.10
Total (4+5)	Fixed cost (`/Year) annual use is 240 h	728.16	1170.00	590.40	444.60
A	Fixed cost (`/h)	3.03	4.88	2.46	1.85
B	Operational cost				
1.	Wage of 1 operator (` 200/day*), `/h	25	25	25	25
2.	Hiring charges of bullock (300/day*),`/h	75	75	75	75
3.	Repair and maintenance, `/h	1.23	4.17	1.00	1.19
Σ(1 to3)	Total operational cost `/h	101.23	104.17	101.00	101.19
(A+B)	Machinery cost, (`/h)	104.27	108.00	103.46	103.04
	Machine capacity	0.0600	0.0360	0.0390	0.0160
Total machinery cost in, (`/ ha)		1737.79	3000.00	2652.82	6440.00

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