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 425.37cm³ 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. Sowing 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.
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.

Fig 1 Share of the maize ridger

Fig 2 Landside (a) and frog (b) of developed maize ridger
The plant height and row spacing were affected 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.

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

The plant height and row spacing were affected by 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.
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°16’N latitude and 81°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/m³ 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 trial 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 1.85 t/m³. The height of plant of maize crop, moisture content, and bulk density of soil during ridging operation is presented in Table 2.
Table 1. Width, height and volume of soil handled by the ridger

| Parameter | Width, cm | Height, cm | Volume handled, cm³ |
|-----------|-----------|------------|---------------------|
| 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              |

Table 2. 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/m² |
|-------|------------------|--------------------------|--------------------------|-------------------|
| 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 – 51 cm (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 cm (0.05 ha/h) 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).

Table 3. Field capacity and field efficiency of developed ridger

| Parameters | EFC=effective field capacity | TFC=theoretical field capacity | PE=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

The maximum theoretical field capacity was observed with S4 – 51 cm (0.09 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).

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, 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).
Table 4. Effect of different ridging technology on ridge dimension and volume of soil cut.

| Parameters/ Treatments | Dimension of ridge | Volume, cm³ |
|------------------------|--------------------|-------------|
|                        | 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       |

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   | 1.21*           | 13.00                  |
| T2                    | 1.44        | 72.25       | 0.0287     | 0.0158     | 54.65   | 10.48           | 59.25                  |
| T3                    | 1.73        | 69.50       | 0.0733     | 0.0548     | 74.64   | 2.02*           | 51.50                  |
| T4                    | 1.30        | 76.75       | 0.0698     | 0.0360     | 51.62   | 27.42           | 68.25                  |

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

| S. No. | Particular                        | Maize ridger | Rider plough | Tendua plough | MB plough |
|--------|-----------------------------------|--------------|--------------|---------------|-----------|
| 1.     | Cost of machine, ₹                | 2960.00      | 7500.00      | 2400.00       | 2830.00   |
| 2.     | Life of the machine (y)           | 10           | 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 to 3) | 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, (/ha)        | 1737.79      | 3000.00      | 2652.82       | 6440.00   |

REFERENCES

[1] ANONYMOUS. 2013. http://agropedia.iitk.ac.in/content/maize-price-forecast-2013-14a
[2] AHMAD, W., AHMAD, A.U. H., ZAMIR, M. S. I., AFZAL, M.A., MOHSIN, U., KHALID, F. AND GILLANI, S. M. W. 2012. Qualitative and quantitative response of forage maize cultivars to sowing methods under subtropical conditions. The Journal of Animal & Plant Sciences, 22(2):318-323.
[3] BIRKAS, M., GYURICZA, C., PERCZE, A. AND SZALAI, T. 1998. Experiments with ridge tillage for maize in a brown forest soil. Noventyemer, 47(5) 559-57.
[4] THAKUR, H.S., GIROTHIA, O.P., HOLKAR, S., & SHARMA, R.A. 2003. Effect of Land Treatments on Productivity of Rainfed Maize (Zea Mays L.) Varieties Grown on Vertisols of Madhya Pradesh. Crop Resessch Hisar 26(1), 75-78.
[5] KHAN, J.N., DIXIT, J., SHUKLA, R.M. 2010. Mechanization possibilities of maize cultivation in hilly regions of Jamnu and Kashmir state of India. Agricultural mechanization in Asia, Africa, and Latin America 41(3).
[6] RANAWAT, Y., RAM, H., SISODIA, S.S. AND N.K. PUNJABI 2011. Adoption of improved maize cultivation practices by trained and untrained farmers of kvk, Udaipur. Raj. J . Extn. Edu., 19144 -147.
[7] THOMAS, A.L. AND KASPAR, T.C. 1997. Maize nodal root response to time of soil Ridging. Agronomy journal, 89(2)195-200.
[8] RAGHAVENDRA, VEERANGOUDA, M., PRAKASH, K. V., PALLEDD, V. K., HIREGOUDAR, S. K., AND MASKI, D. 2013. Development and evaluation of ridge planter for cotton. Karnataka J. Agric. Sci.,26 (1) : (88-91) 2013