Comparative performance evaluation of different ploughs used in Biasi system of rice cultivation

Ram Prakash Kumar, Tankesh Kumar and Vijay Kumar Singh

Abstract
Biasi is an intercultural operation of ploughing the field of standing crop in stagnant water to suppress weeds, stir the soil, thinning and manipulate the root zone of the crop. Traditionally, it is performed by desi plough which requires much time and leads to excessive plant mortality. The aim of this paper was to present a comparative study of the performance of different ploughs used in biasi. The operation was carried out in the paddy field using three types of plough viz., desi plough, 3-tined biasi plough and 5-tined biasi plough. Various field parameters like plant mortality, weeding efficiency, field efficiency, draft of the plough, speed of operation, power requirement, energy requirement, number of effective tillers, panicle length, panicle weight and harvest index were determined. 5-tined biasi plough showed the highest field efficiency (75%) and weeding efficiency (73.33%), with the lowest plant mortality (28.91%). Crop conditions and harvest index were observed to be better with the 5-tined biasi plough compared to other ploughs. It was found that the cost of operation (Rs. 494.51/ha) and total energy requirement (203.81 MJ/ha) of 5-tined biasi plough were low. These results indicate that 5-tined biasi plough demonstrated the best performance and improved the yield at a minimal cost.

Keywords: Biasi, 5-tined biasi plough, plant mortality, weeding efficiency, field capacity

Introduction
Rice is grown on an area of about 44 M ha in India, of which 40% area is rainfed lowlands mostly located in the eastern states of India viz., Assam, Bihar, Orissa, West Bengal, and Chhattisgarh. In 50-80% of this area, rice is cultivated by broadcasting followed by biasi method (Nayak and Lenka, 1988) [2]. Presently in Chhattisgarh, about 75% area is under broadcasting biasi, 15-17 percent under transplanting and 8-10% area is covered by direct drilling method of rice cultivation (Pandey et al., 2018) [3]. ‘Biasi’ is an intercultural operation for control of weeds in rice fields. Traditionally it is done by ploughing the field with indigenous plough in 100 to 250 mm standing water when the crops attain the age of 30-45 days. After biasi operation, disturbed rice seedlings are again transplanted and filled the gap simultaneously majority of weeds are buried in the soil manually by labourers is known as ‘Chalai’. Traditional biasi method has many disadvantages such as high plant mortality, low weeding efficiency, low field capacity, low productivity, and more energy requirement. Pandey et al., (2018) [3] reported that the energy requirement was high and yield was low in traditional biasi system of rice cultivation Traditional biasi system of rice cultivation. Kawade (2001) [1] designed and developed a biasi implement having three furrow openers for biasi operation. It was reported that improved biasi implement gave 28.9% higher field capacity, 33.37% less plant mortality and 14.20% more weeding efficiency over traditional (desi) biasi plough. It was found that the cost of operation with improved biasi plough was significantly lower than the traditional biasi plough. Owing to very few published studies on improvement of biasi-implement, the experiment was conducted to evaluate the performances of 5-tined biasi plough, 3-tined biasi plough and desi plough for biasi operation.

Materials and Methods
The study was conducted with paddy crop (Variety-Supreme sonam) in the farmer’s field at Chatarkhar village of Mungeli district (Chhattisgarh) during kharif season in year 2014-15. A skilled worker and a pair of local buffaloes were employed, and necessary instructions were given prior to take up the work. Field was prepared using the local wooden indigenous plough and levelled with planker (Pata). The experimental field was divided into three plots. The sowing was done by broadcasting paddy seeds of Supreme sonam variety at the seed rate.
of 125 kg/ha as per prevailing farmers practice. Necessary plant protection practices were followed time to time. Biasi operation was carried out with three types of plough viz., desi plough, 3-tined biasi plough and 5-tined biasi plough at 13-15 cm depth of water in the field at 37 days after sowing (DAS). Chalai operation was performed after biasi. Various field parameters and yield attributes were determined before and after biasi operation. Specifications of field and animals are given in Table 1. The different types of ploughs used for biasi operation are shown in Fig. 1, Fig. 2 and Fig. 3, respectively, and their specifications are given in Table 2.

<table>
<thead>
<tr>
<th>Table 1: Specification of ploughs</th>
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<tbody>
<tr>
<td><strong>Particulars</strong></td>
</tr>
<tr>
<td>Source of Power</td>
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<tr>
<td>Material</td>
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<tr>
<td>Share</td>
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<tr>
<td>Length (cm)</td>
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<td>Width (cm)</td>
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<td>Height (mm)</td>
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<td>Weight (kg)</td>
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<tr>
<td>Weight of Yoke (kg)</td>
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<td>Cost (Rs.)</td>
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</tbody>
</table>

![Fig 1: Desi plough.](image1)

![Fig 2: 3-tined biasi plough.](image2)

![Fig 3: 5-tined biasi plough.](image3)

<table>
<thead>
<tr>
<th>Table 2: Specification of animal and Field</th>
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</thead>
<tbody>
<tr>
<td><strong>Field Condition</strong></td>
</tr>
<tr>
<td>Kind of soil</td>
</tr>
<tr>
<td>Size of experiment plot (each plot)</td>
</tr>
<tr>
<td>Length (m)</td>
</tr>
<tr>
<td>Width (m)</td>
</tr>
<tr>
<td>Area (m²)</td>
</tr>
<tr>
<td>Type and character of soil</td>
</tr>
<tr>
<td>Depth of standing water (cm)</td>
</tr>
<tr>
<td>Avg. height of plant (cm)</td>
</tr>
<tr>
<td>Plant population per m²</td>
</tr>
<tr>
<td>Age of the crop (Days)</td>
</tr>
</tbody>
</table>

**Evaluation procedure**

**Plants Mortality**
The plants mortality was calculated by using the following formula:

\[
\text{Plant Mortality (\%) } = \frac{P_1 - P_2}{P_1} \times 100
\]  

(1)

where,

- \(P_1\) = Number of plants per square meter before the biasi operation
- \(P_2\) = Number of plants per square meter after the biasi operation

**Weeding Efficiency**
The weeding efficiency was calculated by using the following formula:

\[
\text{Weeding Efficiency (\%) } = \frac{W_1 - W_2}{W_2} \times 100
\]  

(2)

where,

- \(W_1\) = Number of weed per square meter before biasi operation
- \(W_2\) = Number of weed per square meter after biasi operation

**Theoretical field capacity**
Theoretical field capacity (ha/h) of ploughs was calculated by using the following formula:

\[
\text{Theoretical Field Capacity (ha/h) } = \frac{W \times S}{10}
\]  

(3)

where,

- \(S\) = Speed of operation, km/h
- \(W\) = Theoretical width covered by implement, m
Effective field capacity

Effective field capacity (ha/h) of ploughs was calculated by using the following formula:

\[ \text{Effective Field Capacity (ha/h)} = \frac{A}{T} \]  

(4)

where,

- \( A \) = Actual area covered, ha
- \( T \) = Total time required to cover the area, h

Field Efficiency

Field efficiency (%) of ploughs was calculated by using the following formula:

\[ \text{Field Efficiency (\%)} = \frac{\text{Effective Field Capacity}}{\text{Theoretical Field Capacity}} \]  

(5)

Draft of the plough

The draft was measured by using the spring dynamometer ranging from 0-100 kg. It was attached between the implement and yoke with the help of hook end of the dynamometer. The observations of pull where recorded during each pass of implement in the selected five rows. The draft was calculated after determining the angle of pull as follows:

\[ \theta = \tan^{-1}\left[\frac{(v-h)}{L}\right] \]  

(6)

\[ D = P \times \cos \theta \]  

(7)

where,

- \( \theta \) = Angle between the line of pull and horizontal, degree
- \( v \) = Vertical height up to the neck of the he-buffalo from the ground, m
- \( h \) = Height of hitch of implement from ground, m
- \( L \) = Horizontal distance between hitch point and the neck of Buffalo, m
- \( D \) = Draft, kg
- \( P \) = Pull (dynamometer reading), kg

Speed of operation

The speed of operation was measured by recording the time required to cover 10 m distance in field during operation. Time was measured with the help of stopwatch then speed of operation was calculated by the following formula:

\[ \text{Speed (km/h)} = \frac{3.6 \times \text{Distance travelled (m)}}{\text{Time (h)}} \]  

(8)

Power requirement

The power requirement of implements was determined from the draft and speed using the relation:

\[ P = D \times S \]  

(9)

where,

- \( P \) = Power, Kw
- \( D \) = Draft, Kn
- \( S \) = Speed, km/h

Energy Requirement

The energy required in operation per hectare was calculated by multiplying standard energy equivalents per man, implement or animal with number of hours of work in each operation.

Crop yield attributes

The number of tillers in 1 m² was counted from marked sections before harvesting of the experiment plot. The number of grains per panicle were determined by threshing ten panicles manually and computed by taking average of all. The thousand grain weight was also determined by weighing one thousand grains from representative ear heads from the market section.

Plant population

The plant population was determined as the mean value of the number of plants per square meter at three random places of each plot.

Number of effective tillers per square meter

Number of effective tillers was calculated as the number of ear bearing tillers per square meter after flowering stage at 90 DAS. Average of number of tillers at three random places of each plot was taken.

Panicle length

Panicle length was measured from the neck of the node to the tip of the panicle. It was calculated as the average of 5 panicles selected randomly from the harvested product.

Panicle weight

Five panicles were selected for measurement of length and weight and their mean was calculated.

Grain yield

Grain yield was measured by converting the average weight of clean grains recorded from three random places of each plot in to q ha⁻¹.

Straw yield

The straw yield was determined by converting the average weight of straw taken from three random places of each plot in to q ha⁻¹.

Harvest index (HI)

The harvest index was calculated by dividing the economic yield (grain yield) with biological yield (grain and straw yield) and multiplying by 100.

\[ \text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \]  

(10)

Economic evaluation

In order to determine the economy of the biasi operation with different biasi ploughs, cost of fabrication and operation were calculated. The cost of operation was calculated considering fixed and variable cost taking the unit purchase price, annual use, salvage value, interest rate, maintenance cost and life of implement.

Fixed cost

(a) Depreciation

\[ \text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \]  

(11)

where,

- \( P \) = Unit Price, Rs.
- \( S \) = Salvage value, 10% of the unit price, Rs.
- \( N \) = Total life, years
(b) Interest

\[
\text{Interest (Rs.)} = \frac{P + S}{N} \times \frac{R}{100}
\]  
(12)

where,

\[R = \text{Interest rate (\%)}\]

(I). Variable cost

It includes fuel cost, lubricants, repairs, maintenance, and other costs.

Fuel cost

Fuel cost was calculated on the basis of actual fuel consumption of the machine.

Repairs and maintenance

Cost of repairs and maintenance was taken as 10 per cent of the initial investment of the machine.

Other costs

It includes wages for operator, labour cost based on the prevailing market rates per day of 8 hours.

Results and Discussion

Field performance of different biasi ploughs

Plant mortality is one of the greatest problems in biasi operation. Before biasi operation, the average plant population was 294 in the field and after biasi operation, it was 191, 198 and 209 for 5-tined biasi plough, 3-tined biasi plough and desi plough respectively. The lowest plant mortality (28.91\%) was found for 5-tined biasi plough compared to 3-tined biasi plough (30.05 \%) and desi plough (31.04\%). The reason for this may be the minimum number of passes and less clogging during biasi with improved biasi plough.

Highest weeding efficiency was observed for 5-tined biasi plough (73.33\%) followed by 3-tined biasi plough (69.23\%) and desi plough (57.14\%). High weeding efficiency of 5-tined biasi plough may be due to closer spacing of tines and tampering by the movement of he-buffalo, which might have suppressed more weeds.

The field capacity depends upon the working width of the implements and speed of operation. The unclogging time and number of unclogging of the implement also affect the time required to cover the area and consequently field capacity of the implement. 5-tined biasi plough showed the highest theoretical and effective field capacity of 0.090 ha/hr and 0.0675 ha/hr, resulting in the highest field efficiency (75.00\%).

The draft requirement was more for 5-tined biasi plough (62 kgf) as compared to 3-tined biasi plough (56 kgf) and desi plough (43 kgf). The reason for more draft of improved biasi plough attributed to the high weight of the implement and more number of tines.

The speed of the desi plough was highest (2.6 km/hr) followed by the 3-tined biasi plough (2.2 km/hr) and 5-tined biasi plough (1.8 km/hr). This may be because of the lower draft of the desi plough.

The highest power requirement was observed in 5-tined biasi plough (0.372 kW) as compared to 3-tined biasi plough (0.335 kW) and desi plough (0.297 kW). It may be due to the higher draft of 5-tined biasi plough.

<table>
<thead>
<tr>
<th>Field performance parameter</th>
<th>Desi plough</th>
<th>3-tined biasi plough</th>
<th>5-tined biasi plough</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual operating time (hr)</td>
<td>2.46</td>
<td>1.14</td>
<td>0.79</td>
</tr>
<tr>
<td>Area covered (ha)</td>
<td>0.0533</td>
<td>0.0533</td>
<td>0.0533</td>
</tr>
<tr>
<td>Travelling speed (km/hr)</td>
<td>2.6</td>
<td>2.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Theoretical field capacity</td>
<td>0.0264</td>
<td>0.066</td>
<td>0.090</td>
</tr>
<tr>
<td>(ha/hr)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective field capacity</td>
<td>0.0179</td>
<td>0.047</td>
<td>0.0675</td>
</tr>
<tr>
<td>Speed of operation</td>
<td>2.6</td>
<td>2.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Power output (kW)</td>
<td>0.297</td>
<td>0.335</td>
<td>0.372</td>
</tr>
</tbody>
</table>

The energy required for the operation by desi plough was higher (540.195 MJ/ha) as compared to 3-tined biasi plough (386.45 MJ/ha) and 5-tined biasi plough (203.81 MJ/ha). Less energy input for biasi operation with the 5-tined biasi plough might be due to more field capacity.
Effect of different *biasi* ploughs on yield attributes

The yield attributes like number of effective tillers, panicle length, panicle weight, grain yield, straw yield and harvest index were observed to be slightly higher in case of *biasi* operation with 5-tined *biasi* plough as presented in Table 4. This was probably due to improved manipulation of soil, distribution of plants and better weed control, which results in better crop establishment.

**Table 4:** Effect of different *biasi* ploughs on yield attributing character and grain yield

<table>
<thead>
<tr>
<th><em>Biasi</em> ploughs</th>
<th>Desi plough</th>
<th>3-tined <em>biasi</em> plough</th>
<th>5-tined <em>biasi</em> plough</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant population</td>
<td>191</td>
<td>198</td>
<td>209</td>
</tr>
<tr>
<td>Number of effective tillers (m⁻²)</td>
<td>274</td>
<td>345</td>
<td>393</td>
</tr>
<tr>
<td>Panicle length (cm)</td>
<td>19.6</td>
<td>20.5</td>
<td>21.1</td>
</tr>
<tr>
<td>Panicle weight (g)</td>
<td>2.15</td>
<td>2.31</td>
<td>2.36</td>
</tr>
<tr>
<td>Grain yield (q/ha)</td>
<td>32.66</td>
<td>33.13</td>
<td>34.04</td>
</tr>
<tr>
<td>Straw yield (q/ha)</td>
<td>49.5</td>
<td>46.93</td>
<td>46.89</td>
</tr>
<tr>
<td>Harvest index</td>
<td>39.75</td>
<td>41.38</td>
<td>42.06</td>
</tr>
</tbody>
</table>

Cost of operation

The cost of operation was found to be minimum for the 5-tined *biasi* plough (Rs. 494.51 per ha) compared to 3-tined *biasi* plough and *desi* plough. This might be due to the higher field capacity of the 5-tined *biasi* plough.

**Fig 7:** Cost of operation and yield of different *biasi* ploughs.

Conclusion

Among the three ploughs, the 5-tined *biasi* plough was found to be best for *biasi* operation with respect to the field performance as well as yield attributes of crop. Study revealed that the cost of operation with 5-tined *biasi* plough was less. The findings of the study may provide significant help for the implementation of 5-tined *biasi* plough in the field at large scale and further study to improve the *biasi* operation.

References