International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(1): 2136-2140

Received: 17-11-2018
Accepted: 21-12-2018

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

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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.

Fig 1: *Desi* plough.

Fig 2: 3-tined *biasi* plough.

Fig 3: 5-tined *biasi* plough.

Table 1: Specification of ploughs

Particulars	*Desi* plough	3-tined *biasi* plough	5-tined *biasi* plough
Source of Power	One pair of he-buffalo	One pair of he-buffalo	One pair of he-buffalo
Material	Wood	Mild Steel	Mild Steel
Share			
Length (cm)	32	14.5	14.5
Width (cm)	10	7	7
Height (mm)	880	620	620
Weight (kg)	14	18	23
Weight of Yoke (kg)	5	5	5
Cost (Rs.)	1000	1400	1790

Table 2: Specification of animal and Field

Field Condition		Animal Condition	
Kind of soil	**Clay**	**Breed**	**Non-descript**
Size of experiment plot (each plot)		Sex	Male
Length (m)	47	Age	6 Year
Width (m)	34	Weight	850 kg/pair
Area (m^2)	1598	Physical condition	Good
Type and character of soil	*Kanhar*		
Depth of standing water (cm)	13		
Avg. height of plant (cm)	25.8		
Plant population per m^2	285		
Age of the crop (Days)	37		

Evaluation procedure

Plants Mortality

The plants mortality was calculated by using the following formula:

$$\text{Plant Mortality (\%)} = \frac{P_1 - P_2}{P_2} \times 100 \quad (1)$$

where,

P_1 = Number of plants per square meter before the *biasi*

P_2 = Number of plants per square meter after the *biasi*

Weeding Efficiency

The weeding efficiency was calculated by using the following formula:

$$\text{Weeding Efficiency (\%)} = \frac{W_1 - W_2}{W_2} \times 100 \quad (2)$$

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:

$$\text{Theoretical Field Capacity (ha/h)} = \frac{W \times S}{10} \quad (3)$$

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:

$$\text{Effective Field Capacity (ha/h)} = A/T \quad (4)$$

where,

A = Actual are covered, ha

T = Total time required to cover the area, h

Field Efficiency

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

$$\text{Field Efficiency (\%)} = \frac{\text{Effective Field Capacity}}{\text{Theoretical Field Capacity}} \quad (5)$$

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:

$$ø = tan^{-1}[(v-h)/L] \quad (6)$$

$$D = P \times cos\ Ø \quad (7)$$

where,

$Ø$ = 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:

$$\text{Speed (km/h)} = \frac{3.6 \times \text{Distance travelled (m)}}{\text{Time (h)}} \quad (8)$$

Power requirement

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

$$P = D \times S \quad (9)$$

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 m^2 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.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \quad (10)$$

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

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \quad (11)$$

where,

P = Unit Price, Rs.

S = Salvage value, 10% of the unit price, Rs.

N = Total life, years

(b) Interest

$$Interest\ (Rs.) = \frac{P + S}{N} \times \frac{R}{100} \qquad (12)$$

where,
R = Interest rate (%)

(II). 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%).

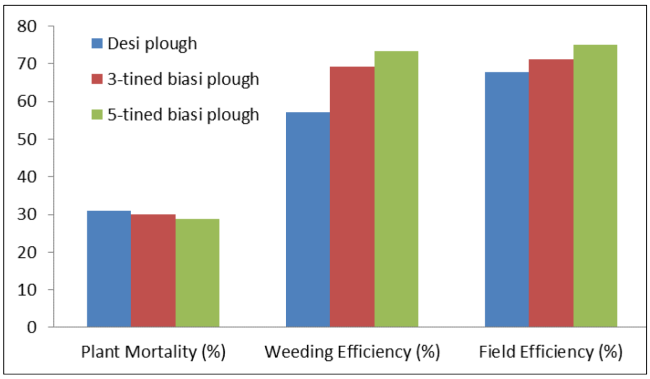

Fig 4: Plant mortality, weeding efficiency and field efficiency of different *biasi* ploughs.

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 3: Field performance parameters of different *biasi* ploughs

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

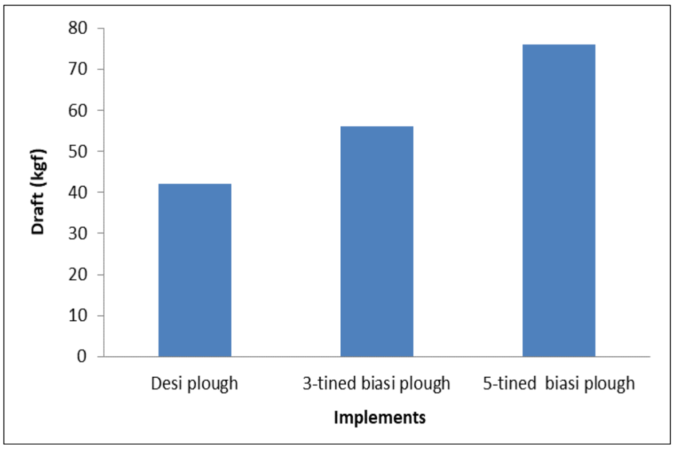

Fig 5: Draft requirement of different *biasi* ploughs.

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.

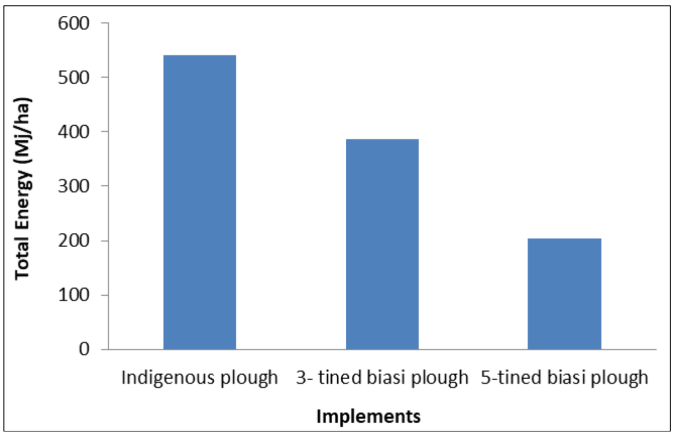

Fig 6: Energy requirement of different *biasi* ploughs.

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

***Biasi* ploughs**	***Desi* plough**	**3-tined *biasi* plough**	**5-tined *biasi* plough**
Plant population	191	198	209
Number of effective tillers (m^{-2})	274	345	393
Panicle length (cm)	19.6	20.5	21.1
Panicle weight (g)	2.15	2.31	2.36
Grain yield (q/ha)	32.66	33.13	34.04
Straw yield (q/ha)	49.5	46.93	46.89
Harvest index	39.75	41.38	42.06

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.

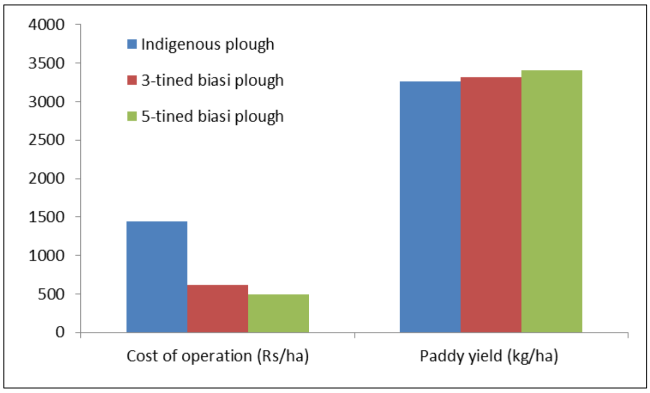

Fig 7: Cost of operation and yield of different *biasi* ploughs.

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.

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