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Performance evaluation of animal drawn multipurpose tool carrier for tillage and Biasi operations

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ABSTRACT : A prototype implement named multipurpose tool carrier (MPT) was developed and tested with ploughing (primary tillage) and Biasi attachments, at the Faculty of Agricultural Engineering, IGKV, Raipur (C.G.). It was developed with design consideration for easy control of animal, sharp turning, adjustment, and comfort to animal and operator. This MPT was developed to prepare seed bed in dry and wet soil condition and to perform various other agricultural operations. The ploughing (primary tillage) and Biasi attachments were tested in sandy loam soil fields. During the field testing the functional performance of universal frame and lifting mechanism and tool attachments was evaluated. The MPT performed well and strength of its components were found good as no break down was observed except loosening of nut-bolts at initial stage. The utilization of power during the operation of ploughing (primary tillage) and Biasi operation was 0.47 and 0.45 kW with 2.13 and 2.33 km/h speed, respectively in the field. The average field capacity of above attachments *i.e.* ploughing (primary tillage) and Biasi attachments in field was found to be 0.0958 and 0.112 ha/h.

KEY WORDS : Biasi, Economical evaluation, Field efficiency, MPT, Tillage

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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 per cent net sown area is cultivated by animal power source. In Chhattisgarh majority of the animals used in agricultural work belong to non descript breed. These animals are small to medium size (250 to 450 kg) with a draughtability of 10 to 12 per cent of their body weight (AICRP on UAE Report 2005). Biasi is a local term used for wet ploughing or intercultural operation, carried out in the standing rice crop (Shrivastava *et al.*, 1987 and Anonymous, 1996).

The Biasi system of rice cultivation is an accepted practice of farmers in the eastern region of the country. Mishra *et al.* (1993) observed that improved Biasi practice in paddy field reduce the plant mortality by 16-30 per cent with increased crop yield of 33-38 per cent over the traditional biasi cultivation. Jogdand and Chauhan (2001) also supported the mechanized intercultivation operation in paddy to reduce drudgery on operator and for uprooting weeds in line sown paddy crop. Tillage is the basic operation in farming. It is done to create favourable conditions for seed placement and plant growth. This is done mainly with a plough. Primary tillage is more aggressive, deeper, and leaves a rougher soil surface relative to secondary tillage. Naderloo *et al.* (2009) reported that effects of tillage depth and forward speed on draught of three primary tillage implements were studied by using a tension load cell in clay loam soil. Implements included a moldboard plough, a disk plough and a chisel plough. A photoelectric speed sensor was used for measuring forward speed. A significant increase in draught was observed for all the implements with increase in tillage depth and forward speed.

The present study attempts to give an overview of previous works toward development of animal drawn tillage tools and to identify the areas having most potential for future improvement. New methodologies in research are available to improve minimum draught requirement and best soil manipulation performance. Changing implement for every specific operation causes inconvenience and investment of extra money. The animal -drawn wheeled tool carrier is a multipurpose machine designed to perform agricultural operations and to provide transportation where animals are

the main source of power. Various design of MPTs have been developed in other parts of the country suiting to the soil and crop conditions and draughtability of animals of that particular region. In Chhattisgarh, no such work has been carried out in the past. Therefore, an attempt has been made to develop such animal drawn machine, which can perform various field operations by changing tools for different specific operations. Ojha and Michael (2005) have reported about multipurpose tool carriers, known as tool frames for attaching various types of tools for efficient utilization of power source.

METHODOLOGY

The implement, Multi Purpose Tool carrier (will be referred as MPT hereafter in this paper) was fabricated in the faculty work shop and the field experiments were conducted at the Research Farm of Faculty of Agricultural Engineering, IGKV, Raipur (C.G.) situated at 21.160 NL and 81.360 EL at an elevation of 289.56 m mean sea level to evaluate the performance of tillage and Biasi implement for animal drawn multipurpose tool carrier in sandy loam soil. Type of primary tillage and Biasi implements and number of passes were randomized. Sepcification of multi purpose tool carrier with different attachments is given in Table A.

Table A : Specification of multi purpose tool carrier with different attachments

Sr. No.	Particulars	Details
1.	Overall Dimension	
	Length, mm	1050
	Breath, mm	420
	Height, mm	400
2.	Length of beam, mm	2250
3.	Type of transport wheel	Iron wheel
4	Number of transport wheel	2
5.	Diameter of transport wheel, mm	400
6.	Width of transport wheel, mm	65
7.	Tillage operation	
	Number of plough bottoms	2
	Distance between two plough bottoms, mm	300
8	Biasi operation	
	Distance between two tynes, mm	20
	Number of tynes	3
	Radius of curvature of tynes,	Inner : 165 mm
	Furrow Opener: (Shoe type) Combination of wedge and sweep.	Outer : 190 mm
		Length : 135 mm
		Wing width : 70 mm
		Angle : 20?

Experimental details:

The field experiment was conducted with rice (Swarna) with recommended package of practices. The tillage practices were carried out by local bullocks and specific implements in the field. The sowing was accomplished by broadcasting method @ 100 kg/ha as per prevailing farmers practice. The Biasi operation was carried out with local bullocks and specific implement at 12- 15 cm depth of water in the field of 30 DAS as per treatments. Relevant observations of each treatment regarding field conditions of plots and plant were recorded before and after tillage/Biasi operation. During the Biasi operation the implement was lifted to collect and unclog the clogged material to minimize the plant mortality and draught. A skilled operator was employed to operate the implement along with a pair of bullock, and necessary instructions were given to the worker according to the treatment prior to take up the work.

Tillage and biasi implement:

Three animal drawn ploughing (primary tillage) implements namely Tendua iron plough, indigenous plough and modified iron plough were tested for primary tillage attached to MPT. Animal drawn narrow share indigenous plough, Tifal Biasi plough and Biasi implement attached to MPT were used for Biasi operation in the experiment. The indigenous plough is common both for ploughing and biasi in Chhattisgarh. However, the review has suggested that improved plough and Biasi implements are beneficial for rice land preparation. Specification of primary tillage implements is given in Table B.

Table B : Specification of primary tillage implements

Sr. No.	Particulars	MPT attachments	Tendua iron plough	Indigenous plough
1.	Source of power	One pair of bullocks	One pair of bullocks	One pair of bullocks
2.	Material	Iron	Iron	Wood
3.	Share			
	Length, mm	30	30	32
	Width, mm	6.5	6.5	6.5
4.	Height, mm	940	620	880
5.	Weight with beam, kg	68.5	22.5	23

Measurement of implement parameters for ploughing operations:

Draught of implements, speed of operation, power requirement, theoretical field capacity, effective field capacity, field efficiency, size of furrow.

Observation during and after Biasi operation:

Time of Biasi operation, draught measurement, depth of operation, measurement of vegetative parameters, plant, weed population and plant height. After Biasi operation the number of plant and weeds were counted from three places of each

plot. The *Chalai* operation was performed; the time and labour required with each treatment were recorded. Measurement of physical properties of soil. plant mortality, weeding efficiency was recorded.

Economic evaluation:

In order to determine the economics of operation with different ploughing and Biasi operation, the fabrication cost was calculated and cost of operation was determined. The hourly cost of operation was calculated considering fixed and operational cost taking the unit purchase price, annual use, salvage value, interest rate, maintenance cost and life of the implement.

RESULTS AND DISCUSSION

The performance of the ploughing (primary tillage) and Biasi implement, was observed in the actual field condition, with paddy (Swarna) crop, in medium field condition with sandy loam soil. The treatments consisting of different ploughing and Biasi implements were randomly laid out and replicated as per statistical design. Different types of observations were recorded, statistically analyzed and presented under following heads.

The field performances of different types of plough were statistically analyzed and the average values are given in Table 1. The actual field capacity of MPT attachments was 0.0958 ha/h recorded highest followed by Tendua plough and indigenous plough. It is very well reflected that, time required for ploughing operation was the lowest under Tendua plough. The speed of operation was found to be lowest with Tendua plough followed by indigenous plough and MPT attachment. The MPT attachment could work with two bottoms making two furrows simultaneously and hence the speed was lowest due to higher draught of two furrows. In spite of the lowest speed this implement covered the highest area as compared to the other two implements which is reflected as the highest field capacity of 0.0958 ha/h followed by Tendua plough (0.0440 ha/h) and indigenous plough (0.0438 ha/h). Thus, the MPT attachment was able to cover larger area in spite of higher draught, which was within the draught capacity of the non-descript bullocks used in this experiment. The estimated power developed for Tendua plough was highest 0.64 hp followed by indigenous plough (0.63 hp) and MPT attachments (0.63 hp). The unit draught of Tendua plough was 0.89 kg/cm^2 where as for indigenous plough and MPT attachments were 1.04 kg/cm^2 and 1.21 kg/cm^2, respectively which shows the unit draught was lower in Tendua plough than indigenous plough and MPT attachments by 14.42 per cent and 26.44 per cent, respectively. The average cross sectional area of cut was found maximum in the MPT attachments than the other two ploughs. The MPT attachment can be ranked first in capacity and draught requirement in view of the draught capacity of local bullocks. The actual field capacity of indigenous plough was found to be lowest in comparison to both the ploughs. On the basis of implement performance, draught requirement and body weight of local bullocks the MPT attachment was found superior over other ploughing implements. All the observation found satisfactorily and within the range of local bullock in MPT operation. These animals are small to medium size (250 to 450 kg) with a draught ability of 10 to 12 per cent of their body weight (AICRP- UAE, 2004-05).

Effect of plouging on physical properties of soil:

It is obvious that different tillage implements made different sized furrows. Width and depth of furrow varied accordingly the shape and size of furrow openers. MPT attachment furrow opener made the widest furrow of 8.02 cm width, where as the Indigenous plough made the deepest furrow of 12.53 cm depth. Effect of different implements on soil physical parameters eg. Bulk density, moisture content and mean mass diameter by recording observations before and after each treatment. The maximum reduction in MMD was observed after the operation of MPT attachment (71.80 mm) followed by Tendua plough (75.10 mm) and indigenous

Table 1: Field performance of different ploughs

Sr. No.	Particulars	Tendua plough	Indigenous plough	MPT attachments
1.	Pull (kg)	69.45	80.62	90.15
2.	Draught (kgf)	61.04	69.27	80.05
3.	Speed (km/h)	2.88	2.49	2.13
4.	Average width of cut (cm)	7.95	7.19	8.02
				Spacing between two tynes is 30 cm
5.	Average depth of cut (cm)	11.45	12.53	10.80
6.	Theoretical field capacity (ha/h)	0.0228	0.0179	0.0341
7.	Effective field capacity (ha/h)	0.0156	0.012	0.0248
8.	Field efficiency (%)	68.42	67.03	72.72
9.	Power (hp)	0.64	0.63	0.63
10.	Unit draught (kg/cm^2)	0.89	1.04	0.92

plough (73.05 mm). MPT attachments performed better than Tendua plough and indigenous plough for reducing clod size and provided finer tilth. The change in physical properties is good in MPT operation. The depth of MPT attachment was lower as compared to other two because the screw jack type depth adjustment were provided in MPT and for maintaining uniform depth. Rajput (1987) studied on tool carriers reported that the field capacities of ploughing 0.065 ha/h and weeding intercultivation 0.287 ha/h by the use of multipurpose wheeled tool carriers for increasing the work output of draught animal power.

The economics of operation of plough attached with MPT was calculated and the cost of operation was compared with the animal drawn Tendua plough and Indigenous plough. It is revealed from the table that the MPT-Plough attachment saves 606.8 Rs/ha and 597.4 Rs/ha as compared to Tendua Plough and Indigenous plough and also saves 54.06 per cent and 54.27 per cent time as compared to Tendua plough and Indigenous plough, respectively. The time and cost saving of MPT attachments are well as compared to other two due to the lower field capacity of other two single bottom implement.

Field performance of different implement used in Biasi operation:

The Biasi operation was done in 10-15 cm standing water and the observations were recorded and statistically analyzed (Table 3).

The prime factor to drive the implement is powers require to pull the implement and is depending factor of the implement to be used, shape, weight and number of tynes. As per definition draught is horizontal component of the pull. The maximum draught was found in MPT attachments (70.81 kg) which is within the range of local bullock. The speed of operation was noted with different implements while recording pulling force to compute power. The highest speed of operation was observed with T_3; (2.33 km/h) followed by T_1; (1.95 km/h) and T_2; (1.75 km/h). The power exerted by bullocks with different Biasi implements was calculated for the known draught and speed and using formula. The power exerted in Biasi operation was found to be 0.60 hp for MPT attachment, 0.47 hp for Tifal Biasi plough, 0.38 hp for traditional Biasi plough. The power exertion was found well within the range of local bullocks; therefore the Biasi operation done by MPT attachment could be successfully operated by a pair of local medium size bullocks. The field capacity depends upon the working width of the implements and speed of operation. The working width depends on the number of tynes and spacing between two successive tynes. 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. Table 3 above shows the variation of field capacity with respect to different implement. It is obvious from the Table 3 that, Indigenous plough has the highest field efficiency (86.01 %) followed by Tifal Biasi implement and

Table 2 : Economic comparison of MPT-Plough attachment with Tendua plough and Indigenous plough

Sr. No.	Description	Tendua plough	Indigenous plough	MPT- Plough attachment	MPT with All attachment
1.	Investment cost, Rs.	1680	1150	5285	10500
2.	Weight with beam, kg	22.5	23	68.5	--
3.	Cost of operation, Rs/h	52.05	51.4	55.19	56.19
4.	Operating time, h/ha	64.10	83.33	40.27	40.27
5.	Operating cost, Rs/ha	3336.53	4283.33	2222.71	2263.16
6.	Cost saving, Rs/ha	--	--	a) 1113.82 over Tendua Plough	a) 1073.37 over Tendua Plough
				b) 2060.62 over Indigenous Plough	b) 2020.17 over Indigenous Plough
7.	Time saving, %	--	--	a) 37.17 over Tendua Plough	a) 37.17 over Tendua Plough
				b) 51.16 over Indigenous Plough	b) 51.16 over Indigenous Plough

Table 3 : Field performance of Biasi pperation

Sr. No.	Particulars	Tifal Biasi plough, (T_1)	Indigenous plough, (T_2)	MPT attachments, (T_3)
1.	Draught (kgf)	64.98	60.43	70.81
2.	Speed (km/h)	1.95	1.75	2.33
3.	Bulk density (g/cm^3)	1.45	1.47	1.50
4.	Effective field capacity (ha/h)	0.071	0.030	0.112
5.	Field efficiency (%)	81.04	86.01	74.34
6.	Power (hp)	0.47	0.38	0.60
7.	Plant height	28.3	29.8	29.3
8.	Plant population	188	181	176

then MPT-Biasi attachment. However, the indigenous plough showed the lowest field capacity, and the values of it was quite higher for MPT attachment. The reason for lower field efficiency of 3 tyned implements attributed to clogging of soil and plants in between the tynes. Time loss due to unclogging reduced the actual field capacity of MPT attachment and 3 tyned Biasi plough and hence the values of field efficiency for these implements were lower than indigenous plough. The Table 3 indicates the bulk density of the soil under different treatments at 24 h after Biasi operation. The bulk density is the average of reading measured at 5 cm depth. It is clear from the table that there was no predominant variation in soil's bulk density under different treatment. The lowest value 1.45 was observed under T_1 and all other treatments showed higher mean value, which were at par to each other. Kawade (2000) designed and developed Biasi implement for Biasi/intercultural operation and stated that improved biasi implement having three furrow openers was suitable for intercultural operation in 5-10 cm standing water in paddy fields. He reported that improved biasi implement gave 28.9 per cent higher field capacity (0.0528 ha/h), 33.37 per cent less plant mortality (25.94%) and 14.20 per cent more weeding efficiency (48.25 %) over traditional biasi plough. He found that the cost of operation using improved biasi implement was Rs. 148 per hectare compared to Rs. 220 per hectare with traditional Biasi plough, giving thereby saving of Rs. 72 per hectare. He stated that due to Biasi operation, disturbance to the original root zone of rice plants helped in enhancing the plant growth.

Plant population and plant height :

Before starting the Biasi operation, the plant population at 5 random places of 1 sq. meter under each treatment was observed at 30 days after sowing. The data of average of observations recorded is presented in Table 3. Though, the plant population was not uniform at all the places, because of manual broadcasting of seeds, the average plant population under each treatment was almost same.

The Table 3 also indicates the plant height under different treatments before the Biasi operation. The plant height is the average height of 5 plants selected from each quadrates of different treatments. It is clear from the table that there was no predominant variation in plant height under different treatments before the Biasi operation.

Plant mortality and weeding efficiency:

Plant mortality is one of the greatest problems in Biasi operation. During the Biasi operation some plants as well as weeds were eradicated. The plant mortality was calculated by determining plant population before and after treatments. The treatments have significant effect on plant mortality. The lowest plant mortality 9.09 was obtained with T_3 followed by T_1;(12.38), T_2;(22.44). Mishra *et al.* (1993) observed that improved Biasi practice in paddy field reduced the plant mortality by 16-30 per cent with increased crop yield of 33-38 per cent over the traditional biasi cultivation.

The plant mortality decreases in spacing of 20 cm of tynes in the "MPT attachments" due to minimum number of passes in Biasi ploughing and minimum clogging whereas it was found more with indigenous plough due to more clogging and more passes with minimum working width (15 cm). The plant mortality observed less due to staggered position of three furrow openers, which allowed easy flow of mud through them. Plant mortality was also attributed to shape of furrow opener, which affected the soil and plant inversion and stampeded loss. Also some loss took place due to operator's foot. The maximum weeding efficiency was observed in case of T_3; (60.18), followed by Tifal (55.14) and traditional Biasi plough (45.52).

Economical evaluation of developed MPT-Biasi plough attachment and comparison with Tifal Biasi plough and indigenous plough:

The economics of operation of Biasi plough attached with MPT was calculated and the cost of operation was compared with the animal drawn Tifal Biasi plough and indigenous plough. It is revealed from the Table 4 that the MPT-Biasi Plough attachment saves 263.04 Rs/ha and 1263.2 Rs/ha as compared to Tifal Biasi plough and Indigenous

Table 4 : Economic comparison of MPT-Biasi plough attachment with Tifal Biasi plough and indigenous plough

Sr. No.	Description	Tifal Biasi plough	Indigenous plough	MPT- Biasi plough attachment
1.	Investment cost, Rs.	1550	1150	5040
2.	Weight with beam, kg	17.5	23	64
3.	Cost of operation, Rs/h	53.51	52.59	54.95
4.	Operating time, h/ha	14.08	33.33	8.92
5.	Operating cost, Rs/ha	753.66	1753.82	490.62
6.	Cost saving, Rs/ha	263.04	1263.2	a) 263.04 over Tifal Biasi Plough
				b) 1263.2 over Indigenous Plough
7.	Time saving, %	--	--	a) 36.64 over Tifal Biasi Plough
				b) 73.23 over Indigenous Plough

plough and also saved 36.64 per cent and 73.23 per cent time as compared to Tifal Biasi plough and Indigenous plough, respectively (Table 4).

Conclusion:

The multipurpose tool carrier performed well and strength of its components was found good as no break down was observed during the field testing. The use of MPT was much economical than the traditional method. The theme behind developing and introducing the MPT was to develop interest in animal farming and increase sustainable yield and profit.

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