Development and Evaluation of Bullocks Drawn Multipurpose Tool Carrier Suitable for the Eastern Plateau

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Abstract

The Multipurpose Tool Carrier (MPT) was developed to prepare the seed bed in dry and wet soil conditions and to perform various other agricultural operations. Various field operations can be performed with the help of the multipurpose tool carrier (MPT) with minimum investments of time and money. The average field capacity of the attachments, that is, cultivator (with shovel and sweep) and seed drill for dry field were found to be 0.1385, 0.1263, and 0.1758 ha/h. It gave higher field capacity (1 ha/day) with additional savings in the cost of operation. The operational cost of MPT cultivator (with shovel and sweep) and seed drill were found to be 551.54, 415.83, and 622.97 ₹ /ha respectively in comparison to the Tendua plough. It was observed that the use of MPT is much economical than the traditional methods. The fabrication cost of MPT with attachments (cultivator with shovel, sweep, and seed drill) was about ₹ 8000.

Keywords: **multipurpose tool carrier, bullock, cultivation, sowing, weeding**

JEL Classification: C990, Q010, Q160

Paper Submission Date : August 20, 2013 ; Paper sent back for Revision : October 27, 2013 ; Paper Acceptance Date : December 5, 2013

Draught Animal Power (DAP) is still the main source of farm power in India, especially for tillage, sowing, intercultural operations, and rural transport. A large area under crops is still managed by using animals for the above-mentioned farm operations. A survey conducted by AICRP on UAE scheme in 1986-1987 showed that the annual utilization of DAP was in the range of 300 to 1200 hours in different parts of the country as against the ideal utilization of about 2400 hours annually (Srivastava, 1993). In Chhattisgarh, average power availability is 1.09 kW/ha, which is less than the national average of 1.5 kW/ha, with a contribution of animal and human power as 27.4% and 48.39% respectively (Mishra & Tripathi, 2006). In Chhattisgarh, on an average, 80% farmers belonging to the marginal and small category have less than 2 hectare land holdings with low annual income resulting in low purchase capacity of improved costly machinery or tractors, and therefore, they are dependent on the animals for tillage, sowing, and weeding operations. Power developed by an average pair of bullocks is about 1 hp for usual farm work, and the farmer has to use different implements matching to the draught capacity of the animals for different farm operations. Changing implements for every specific operation causes inconvenience and investment of extra money.

The concept of animal drawn multipurpose tool frame/carrier was introduced about 25 years ago in Africa and India. On the basis of the performance of various multipurpose tool frames, a frame with steel wheels was developed by CIAE (Garg & Devnani, 1992). The multi purpose tool carrier is a good alternative for this problem. Various field operations can be performed with the help of a multipurpose tool carrier (MPT) without investing much amount and time. Preparation of the seedbed is a specialized task, which requires skill, time, energy, and labour in addition to different soil manipulating implements. Various animal drawn implements have been introduced in this region, but are not largely used by the farmers. Development of an animal drawn MPT could be a solution to low use of

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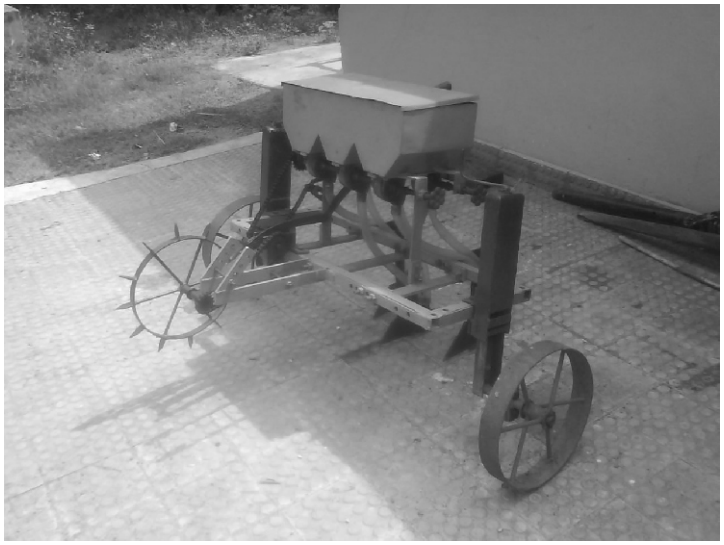
implements under the animal farming system. Use of MPT may increase the quality of seedbed as well as efficiency of operation by saving time and labour. This may further increase the annual utilization of draught animals by performing various tasks on the farm. Different types of MPTs have been developed in many parts of the country based on localized requirements like type of soil, crop, climatic conditions, and draught capacity of animals. The bullocks used for farm operations in Chhattisgarh are mostly of non- descript breed (small and medium-size), with low draught capacity. The MPTs developed in other parts may not be suitable for these bullocks. Hence, a need was felt to develop a Multi Purpose Tool Carrier matching the draught capacity of non - descript bullocks of this region, suiting the local needs.

Materials and Methods

The machine conceived consists of a tool frame, tynes, furrow openers, hitching system, and depth control system. Design of different components of the machine was prepared keeping in view the draught-ability of local bullocks, animal drawn implements being manufactured at the Centre, and used by the farmers in this region. In this implement, row to row distance can be adjusted according to crops' requirement in all operations, and two people can easily handle this implement. Performance of the multipurpose tool carrier was evaluated for secondary tillage, sowing, and weeding operations. Observation of pull, operating time, and turning time in each bed were recorded for all operations. Pull was measured with a spring type dynamometer attached to the beam. The field performance of the multipurpose tool carrier was compared on the basis of draft requirement, actual field capacity, field efficiency, and travel speed of the bullock.

The implement consists of a mainframe and hitching system, cultivator tynes, depth adjustment arrangement, seed metering mechanism, and a power transmission unit: Ground wheel, chain and sprocket, seed and fertilizer metering shaft, and seed and fertilizer box. Locally available suitable materials were used for different components. Mild steel, C 30 angle iron, size 35x35x5 mm was used for the frame and hitch; whereas GI pipe was used for the beam. Tynes were made using MS flat iron of size 50 x 8 mm, and the desired curvature was given to the tynes by forging method and heat treatment. The main frame was strengthened by joining the two angle iron pieces edge to edge, making square cross section, and joining together by welding so that enough strength can be obtained to withstand the load encountered in actual field conditions during the tillage, sowing, and weeding operations. A number of holes (size 10.5 mm) were drilled at a spacing of 50 mm in this frame to accommodate the tynes at different desired spacing as per the requirement. There were attachments to the implement as specified in the Table 1. The Exhibit 1 depicts a schemata of the implement with the sowing attachment.The isometric view of developed MPT, and the overall

Exhibit 1. Multipurpose Tool Carrier with Sowing Attachment



Source: Authors' Research

Table 1. Salient Features of MPT and its Components

S. No.	Particulars		Details
1.	Overall Dimension (L x B x H)mm	:	1050 x 420 x 950
2.	Type of transport wheel	:	Iron wheel
3.	Number of transport wheel	:	2
4.	Length of beam, mm	:	225
5.	Diameter of transport wheel, mm	:	400
6.	Width of transport wheel, mm	:	65
7.	Cultivator-Tyne(W x T x H),mm	:	40 x 10 x 400
8.	Furrow opener (Width of Shovel and Sweep), mm	:	40 and 160
9.	Seed drill	:	
	Metering mechanism	:	Fluted roller
	No. of rows	:	3
	Seed cum fertilizer box (L x B x H), mm	:	600 x 300 x 200
	Power transmission system to seed-drill	:	Ground wheel & chain, sprocket assembly
10.	Cost, ?.	:	8000.00

Source: Authors' Research

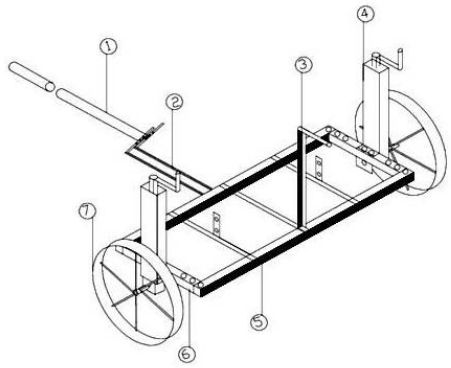
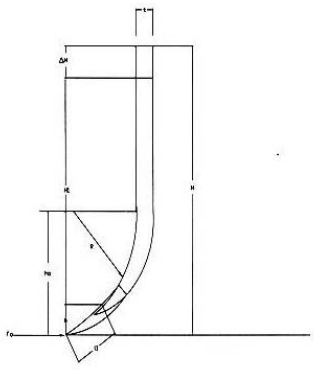
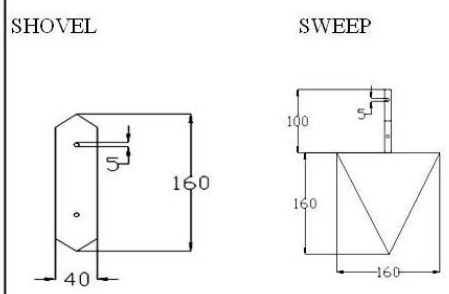


Fig. 1: Multipurpose Tool Carrier





Source: Authors' Research

Fig.2 : Dimension of Tine and Furrow Openers

dimensions are shown in the Figures 1 and 2. The developed MPT was tested for dimensional as well as materials required.

Results and Discussion

Field trials of the MPT along with a Tendua iron plough were conducted at the Faculty of Agricultural Engineering, Indira Gandhi Krishi Vishwavidyalaya, Raipur for seedbed preparation, sowing, and intercultural operations. From the results (Table 2), it can be seen that the MPT is more efficient over the Tendua iron plough. Economic analysis shows that the MPT could provide an effective low cost alternative machinery system, especially when high initial investment on machinery is a major constraint in the adoption of improved technology. The purchase prices show that the MPT may be regarded as a low cost machine than the Tendua iron plough. Mayande, Bansal, and Sangle (1985) reported that a pair of bullocks having 500 kg weight per bullock can consistently generate power in the range of 1.4-1.8 kW at the walking speed range of 3.1-3.8 km per hour operations with wheeled tool carriers.

Table 2. Field Performance of Multipurpose Tool Carrier

Particular	Ploughing			Sowing paddy			Weeding	
	Tendua	MPT Shovel	MPT Sweep	Tandua	Indira Seed-drill	MPT Seed-drill	Cycle wheel hoe	MPT
Moisture content (%)	21.02	18.6	18.0	22.43	21.12	18.8	-	-
Size of implement (cm)	15	60	60	15	60	60	15	60
Average depth of operation (cm)	6.50	6.10	5.13	6.50	5.77	6.10	4.10	6.00
Travel speed of bullock(km/h)	3.33	2.90	2.99	3.39	3.1	2.96	2	2.33
Effective field capacity, (ha/hr)	0.0565	0.1385	0.1263	0.0566	0.1579	0.1558	0.025	0.1156
Theoretical field capacity, (ha/hr)	0.065	0.2	0.188	0.0659	0.1994	0.2053	0.0344	0.14
Field efficiency (%)	76.92	67.37	67.18	85.88	79.18	85.63	72.67	83.78
Draft requirement,(kgf)	57.12	60.10	63.04	57.41	61.23	62.49	72.67	83.78
Power requirement,(kW)	0.44	0.53	0.996	0.44	0.57	0.58	0.45	--
Operating Cost ,(₹/ha)	932.12	380.58	415.83	932.50	354.33	309.53	1044.40	375.14

Source: Authors' Research

The average field efficiency of the MPT cultivator with shovel, sweep, and Tendua plough was found to be 67.37%, 67.18%, and 76.92% respectively. The MPT operated implements showed lower field efficiency than the Tendua plough because time loss in turning at the row ends and removing the clogging was higher for MPT as compared to the Tendua plough . In spite of lower field efficiency, both MPT attachments shoveled and swept higher field capacity than the Tendua plough, and could cultivate a larger area than it in unit time. The effective field capacity for behind MPT Seed-drill, Indira seed drill, and the Tendua plough sowing operation was found to be 0.1558, 0.1579, and 0.050 ha/h respectively, where as the theoretical field capacity was found to be 0.2053, 0.1994, and 0.0659 ha/h for all four crops. From the viewpoint of the effective and theoretical field capacity, the field efficiency of MPT Seed-drill, Indira seed drill, and behind the plough was found to be 85.88 %, 79.18 %, and 85.63 % respectively. Field efficiency for different weeding methods is shown in the Table 2. It shows that the highest field efficiency (83.78 %) was observed under MPT weeder, and 72.67% was observed under the cycle wheel hoe. The MPT-weeder was found to be with the highest field capacity among the manually operated cycle wheel hoe.

The cost of operation was compared with the animal drawn Tendua plough. It is presented in Table 3. It is revealed from the table that the cultivator saves 551.54 and 516.29 ₹/ha as compared to the Tendua plough. The cultivator attached with MPT Shovel and Sweep saved 59.60 and 55.57 times respectively as compared to the Tendua plough. The unit cost of the prototype bullock drawn seed-drill attachment for MPT was calculated by calculating the cost of different assemblies. The estimated operating cost of the MPT- seed drill, Indira seed drill, and Tendua plough came out to be 349.22, 354.33, and 1044.40 ₹/ha for behind the plough. Thus, MPT with seed drill attachment and Indira seed drill could save 695.18 and 578.17 ₹/ha as compared to sowing behind the plough. In addition to this, MPT and Indira seed drill could save 67.83 % and 64.15% time over the traditional practices. The Table 3 depicts the

Table 3. Economic Comparison of MPT

Description	Ploughing			Sowing Paddy			Weeding	
	MPT-Shovel	MPT-Sweep	Tendua plough	MPT Seed-drill	Indira seed drill	Tenda plough	MPT-Shovel	Cycle wheel-hoe
Investment cost (₹)	4954.00	4954.00	1680.00	6684.00	5600.00	1680.00	4954.00	820.00
Weight (kg)	50.00	50.00	22.50	50.00	40.00	22.50	50.00	12.00
Cost of operation (₹/h)	52.52	52.52	52.22	54.41	55.95	52.22	52.52	26.11
Operating time (h/ha)	7.24	7.93	17.85	5.68	6.33	17.66	8.65	40.00
Operating cost (₹/ha)	380.58	415.83	932.12	349.22	354.33	1044.40	375.14	1044.40
Cost saving (₹/ha)	551.54	516.29	-	695.18	578.17	-	3531.11	2861.85
Time saving (%)	59.60	55.57	-	67.83	64.15	-	-	-

Source: Authors' Research

comparative cost of weeding by different methods. Cost of weeding by MPT weeder (₹ 375.00) is 2.5 times less than the cost of weeding using a Cycle wheel-hoe (₹ 1044.40). This variation is due to higher field capacity of MPT implement as it is driven by animals.

Conclusion

The MPT developed under the present investigation worked satisfactorily for secondary tillage, sowing, and weeding operations with different attachments for different operations. The performance of the MPT was found to be better than the corresponding traditional practices. This implement could save time, and also increase the efficiency and quality of operations. This implement is a versatile implement and can be used for several field operations by changing the attached implement only. The universal frame of MPT provides suitability to set the spacing of cultivator and seed drill tynes. The telescopic system facilitates raising and lowering of the implement to adjust the operational depth. It performs tillage (secondary tillage), sowing (seed cum fertilizer drill), intercultural operations (weeding, harrowing). The draught of all the tested implements was below the draught capacity of local bullocks, evaluated under the AICRP on UAE in the previous years, and hence, the implements tested under this experiment may be operated in large fields for longer duration. MPT provides better management to farmers by performing multi tasking operations, and saving time, labour, and money. Thus, it has been proved to be an economical tool carrier for farmers with small land holdings.

Wheeled tool carriers continue to be an important element in the improved soil- and crop-management technologies developed at Indira Gandhi Krishi Vishwavidyalaya, Raipur. Thus, the need for a substantially low-cost machine led us to develop a third design called the MPT. The MPT is a relatively light-weight machine of simple construction. Its performance was satisfactory while it was tested in the research station. The lower cost of the (₹ 8000.00) carrier is expected to make it more acceptable in those regions where there is a need for improved animal-drawn equipment.

References

Garg, B.K., & Devnani, R.S. (1992). *Operators manual for animal drawn multipurpose tool frame*. Bhopal: Central Institute of Agricultural Engineering (CIAE).

Mayande, V. M., Bansal, R.K., & Sangle R.D. (1985). Performance of various animal drawn wheels tool carrier systems. *Journal of Agricultural Engineering ISAE, 22* (2), 27-39.

Mishra B.P., & Tripathi R.S. (2006). *Availability of farm power and mechanization planning for India and Chhattisgarh* (pp. 341-349). National Symposium on conservation and management of agro-resources in accelerating the food production for 21st century, 14-15th December, IGKV, Raipur (C.G.), India.

Srivastava, N. S. L. (1993). *Perspective planning for increased utilization of animal energy*. 4th Annual Workshop of AICRP on Utilization of Animal Energy, CTAE, Udaipur.