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Effect of mechanization on cost-economics of maize cultivation by small farmers of Gajapati District, Odisha

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Abstract
Maize is the one of the highest yielding cereals. Area under maize cultivation in the country, as well as in state of Odisha is gradually increasing due to its high economic benefits from maize. However, the benefits obtained by small and marginal farmers are comparatively less than the large maize farmers due to the use of traditional method of cultivation, use of conventional tools and machineries and small land holding. Most of the unit operations in maize are generally carried out manually which is labour intensive thereby increasing the cost of cultivation. Therefore, in this study a set of improved animal powered machineries and implements were demonstrated in maize cultivation in order to study the gain in net benefits by adopting small farm mechanization. The study revealed that small and marginal maize farmers of Gajapati districts could save up to Rs 7490/- per hectare using the improved bullock drawn implements and the B:C ratio has been increased up to 2.63 as compared to 2.08 in case of conventional maize farming.

Keywords: Mechanization, Rice-green gram cropping system, conservation farming.

Introduction
Maize, is considered as the queen of cereals in India because of its huge utility as food, feed and fodder apart from its use as snacks. The demand of maize has been remarkable after introduction of sweet corn, baby corn, popcorn which have almost captured the Indian market (Sagar *et al.*, 2019) [6]. Today, maize is the third largest food crop in India in terms of area and is growing fast due to the higher benefits from crop. The farmers are aware of the fact that maize is a high feeder crop with comparatively higher investment; still they prefer it due to higher net return. In this context, maize is most preferred diversified crop in the country and is even promoted for food security of country (Taipodia and Sukla, 2013) [9]. In India not only production and consumption of maize have been rising consistently, but also the consumption pattern of this food crop has also changed over the years (Kumar *et al.*, 2012) [3]. Mechanization of farms helps in reduction of human drudgery besides ensuring the timeliness of operation and solving the problem of scarcity of labours during peak cropping season (Thakur *et al.*, 2016) [10]. Several initiatives have been implemented at national and state level for pushing agricultural mechanization in all leading crops. Setiawan *et al.* (2006) [8] reported that the government should encourage manufacturers of agricultural machinery locally for manufacturing agricultural machineries that is affordable by the farmers (Setiawan *et al.* 2006) [8]. Sariningpuri *et al.* (2017) [7] suggested several attempts to be taken to increase profits in corn cultivation, among others: the efficient use of agricultural machinery, professional workforce efficiency, as well as improving the work of agricultural machinery in accordance with the engine capacity. Dixit *et al.* (2017) [2] reported that a number of suitable improved tools, implements and machinery were identified, procured/developed and evaluated by Division of Agricultural Engineering, SKUAST-K, Srinagar to bridge the existing mechanization gap for hilly regions of Jammu and Kashmir state and suggested that the results for benefit of extension workers and users.
Maize is the most important major coarse cereals grown in the state after rice in an area of 279.61 thousand hectare with a production of 7.79 lakh metric tonnes (Odisha Agricultural

Statistics, 2013) [5] while districts like Nawarangpur, Rayagada, Gajapati, Ganjam, Keonjhar, Mayrbhanj and Koraput are leading districts for its cultivation. Incidentally, these districts are dominated by small and marginal farmers who depend on human and animal power for different agricultural operations. The All India Coordinated Research Project (AICRP) on Utilization of Animal Energy (UAE), Odisha University of Agriculture and Technology has been consistently developing animal drawn improved implements for different agricultural operations, suitable for small and marginal farmers of the state. While a good number implements have been developed for tillage and sowing operation of maize through this project, few initiatives were also taken up with special reference to the problems identified in this district such as development of fertilizer applicator cum ridger for maize crop for simultaneous application of fertilizer in two rows and covering it with soil by a ridger following the fertilizer application. Traditionally, fertilizer application is done by manual dropping near the plant in bending posture which also involves high drudgery and uneconomical too. So, simultaneous ridging and fertilizer application are highly essential for reducing the cost of cultivation and make the unit operation profitable. A bullock drawn weed remover was developed in the Project to remove weeds and grasses from the ploughed field. It consists of a M.S. frame of square bar, two handles, collecting rakes having pegs with lift up lever mechanism, ground wheel for transportation and depth control during operation. It was proposed to be used before sowing of maize seed in farmers' field. It was proposed to sow maize seeds through five row seed cum fertiliser drill (UAE, 2019) [1] after ploughing by OUAT mould board (MB) plough, developed by AICRP on UAE project. The small and marginal maize growing farmers of the state use manual tubular maize shellers after manual dehusking of maize cobs. In some places, tractor operated axial flow threshers are used on hiring basis through middle men. In either case, the process is time consuming and drudgery prone or costly and unwarranted being exploited by middle men. It is therefore proposed to develop a maize dehusker cum sheller for simultaneous dehusking and shelling of maize that to be operated by bullock power in rotary mode by the small marginal farmers where bullock farming is predominantly adopted. Dixit *et al.* (2012) [3] developed a foot operated maize cob sheller and reported that the shelling capacity of the equipment was 24.27 q/hr with shelling efficiency of 97.32 % and grain damage of 5.31 %.

A study was conducted to assess the benefits of using the improved bullock drawn implements in maize cultivation in the district Gajapati and compared it to the conventional method of maize cultivation. For this purpose, field evaluation of the OUAT MB plough, OUAT weed remover and threerow multi crop seed cum fertilizer drill for sowing of maize and the modified bullock drawn fertilizer applicator-cum-ridger for intercultural operation in maize crop were carried out as a package demonstration in farmers' field. The newly developed maize dehusker cum sheller, operated by bullock power in rotary mode was also evaluated. This was undertaken to reveal the economic benefits of using the package of bullock drawn implements in maize cultivation and compare it with the conventional method of maize production and post- harvest operation.

Materials and methods

The field experiment for evaluation of package of implements for maize mechanization was conducted in the village-Pindiki, Block – Mohana, Dist – Gajapati taking four maize growing farmers in the Gajapati district. Out of four farmers each farmer had cultivated 2 acres each in traditional and improved practice. A set of implements like bullock drawn mould board plough, bullock drawn weed remover, five row seed cum fertilizer drill modified to three row seed drill, fertilizer applicator cum ridger were kept in the village. All the operations, starting from land preparation till harvesting are monitored by frequent visits to the village. Only the dehusking and shelling of maize was done in rotary operated maize dehusker cum sheller installed at CAET campus. The details of development of two new machineries i.e., bullock drawn fertilizer applicator-cum-ridger and feed-in type maize dehusker cum sheller are described in the following section.

Development of a bullock drawn fertilizer applicator-cum-ridger

The functional requirement of a bullock drawn fertilizer applicator-cum-ridgeris to perform four main functions, (i) loosening of the soil up to 200 mm depth and cutting the weeds, (ii) placement of chemical fertilizers on the surface of the soil near the root zone at a lateral distance of 50-100 mm from plants (iii) earthing-up the plant and covering the fertilizer. Themachine consists of a number of components which will be assembled on two main units, *viz*, (i) fertilizer placement unit and (ii) ridger unit. Two opposed mould board bottoms similar to Bose plough mould board curvature were welded together for development of ridger bottom which lifts, breaks and turns the furrow slice. The ridger bottom is fairly long with a gradual twist on both sides, the surface being slightly concave from the centre towards periphery. The ridger turns furrow slice to both the right and left side of direction of travel and has the advantage that it will not upset the slope of the land and will leave furrows in between the rows for better inter tillage operation and irrigation. No separate share point has been provided. The share is an integral part of mould board. The weight of the ridger with frame and handle, fertilizer placement unit and pipe beam is 6.80 kg, 10.20 kg and 3.60 kg, respectively. The total weight of the implement without beam is 17.00 kg. The details of specification of the implement are shown under Table 1.

Table 1: Specifications of fertilizer applicator-cum-ridger

Parameters	Specifications
Overall dimensions, mm	
Length, mm	2370
Width, mm	330
Height, mm	1280
Weight without beam (empty), kg	17
Hopper Capacity, kg	4
Ridger Length, mm	330
Ridger Width, mm	232
Ridger Height, mm	235
Ground wheel diameter, mm	350

Development of a feed-in type maize dehusker cum sheller, operated by bullock power in rotary mode

A feed-in type maize dehusker cum sheller is to be operated by bullock power in rotary mode was developed, consisting of a threshing cylinder and blower. The threshing cylinder shaft and blower gets drive from the bullock operated rotary system. The matured and dried maize cobs are put in to the hopper which are dehusked and threshed in the cylinder to separate the grains to fall on the perforated sieve while the blower is used to clean the threshed grains. The threshing unit

operates on the principle of axial flow movement of the material. The threshing elements inside the threshing cylinder comprises of a series of studs arranged in helical manner. There is one blower and one perforated sieve, which are simultaneously engaged for obtaining clean maize grain after threshing. All these operations are accomplished simultaneously. The fabrication work was done at a SSI Unit, M/s Sheet Profile Co. Ltd., Gosani Nuagaon, Berhampur, Ganjam, Odisha. The specification of the feed in type maize dehusker cum sheller, operated by bullock power in rotary mode is placed below. The details of specification of the implement are shown under Table 2.

Table 2: Specification of the Feed in type Maize dehusker cum sheller

Parameters	Specifications
Type	Axial flow
Power	Pair of bullocks
Type of drive	V-belt and pulley
Length, mm	1300
Width, mm	800
Height, mm	1130
Weight, kg	90

Results and discussion

Maize fields were ploughed by bullock operated mould board plough after the onset of monsoon in the month of June, followed by grass cleaning and levelling by bullock operated weed remover (Fig.1).. The five row seed cum fertiliser was converted to three row seed cum fertiliser drill by removing two furrow openers and attachments so as maintain a distance of 60 cm between row to row (Fig.2).. The average plant to plant distance was 25×25 cm and row to row distance was 60×60 cm. The farmers performed top dressing and beusaning after 30 days after sowing (DAS) by bullock operated fertiliser applicator cum ridger (Fig.3). After the crop was matured, the dried maize cobs were brought to CAET campus for dehusking and threshing in bullock operated rotary mode (Fig.4). The observations observed during operation of the set of implements are shown in Tables 3, 4, 5 & 6.

Table 3: Evaluation of bullock drawn weed remover

Particulars	Observations
Location of test	Village-Pindiki, Dist.-Gajapati
Area covered, m^2	2000
Time taken, hr	1.5
Body weight of bullocks, kg	650
Speed of operation, kmph	1.5
Depth of operation, cm	6.4
Draft, N	373
Field capacity, ha/hr	0.169
Field efficiency, %	72.4
Weeding efficiency, %	64.5
Cost of weed removal with weed remover/ha	Rs. 1466.00
Cost of manual weeding/ha	Rs. 3225.00
Saving against local practice	Rs. 1789.00

Fig 1: Field evaluation of weed remover at Pindiki, Gajapati

Table 4: Evaluation of three row bullock drawn seed cum fertilizer drill

Particulars	Observations
Crop	Maize
Variety	P-3401
Type of soil	Sandy loam
Soil moisture, % (db)	20.12
Mean weight diameter of clods, mm	0.36
Average speed, km/hr	1.78
Avg. plant to plant distance, cm	23.8
Average row to row distance, cm	59.7
Depth of seed placement, cm	4.3
Actual seed rate observed, kg/ha	16.3
Draft, N	365 (5.9 % of the body weight)
Effective field capacity, ha/hr hrs/ha	0.22 4.55
Field efficiency, (%) Cost of operation, Rs/ha	61.63 448.75

Fig 2: Field evaluation of three row seed drill at Pindiki, Gajapati

Table 5: Evaluation bullock drawn fertiliser applicator cum ridger

Particulars	Observations
Location of test	Village-Pindiki, Dist. - Gajapati
Bullocks used	Medium pair (650 kg)
Average Soil moisture, %	15.6
Type of soil	Sandy loam
Soil moisture, % (db)	20.12
Bulk density of soil (g/c.c)	1.6
Average speed, km/hr	1.56
Av. actual field capacity, ha/h	0.06
Field efficiency, %	68
Plant damage, %	10.5
Weeding efficiency, %	56.34
Draft requirement, kgf	37.23
Power requirement, hp	0.22 hp
Approximate Cost of Machine, Rs	5000.0
Cost of operation, Rs/ha	1386

Fig 3: Field evaluation of fertilizer applicator cum ridger at Pindiki, Gajapati

Fig 4: Evaluation of maize dehusker cum sheller in rotary mode

The results on performance evaluation of the bullock drawn weed remover indicated that the actual field capacity was 0.169 ha/h with field efficiency and weeding efficiency of 72.4 and 64.5 percent respectively (Table 3). The cost of weeding was found to be Rs 1466.00/ha as compared to Rs 3225/ ha in conventional manual hand weeding method. The results on performance evaluation of bullock drawn seed cum fertilizer drill for line sowing of maize revealed that the actual field capacity was 0.22 ha/h with field efficiency of 61.33 percent and cost of operation of Rs 448.75/ha (Table 4).

The results on functional parameters of different methods of maize cultivation conducted during *Kharif*-2019 season indicated that the average actual field capacity of the bullock drawn fertiliser applicator cum ridger (FAR) was 0.06 ha/h with 68 % field efficiency (Table 5). The average power requirement of FAR was found to be 0.22 hp with average speed of operation of 1.56 kmph and average draft of 37.23 kgf. The results of performance evaluation of the developed maize dehusker cum sheller revealed that the average output 166.2 kg/h with a feed rate of 230.5 kg/h (Table 6). The shelling and cleaning efficiency of the thresher were found out to be 97.42 % and 92.80 % respectively. The cost of operation by the maize dehusker cum sheller was found to be Rs 0.55/kg as compared to Rs 6.20/kg in conventional method.

Table 6: Performance of developed feed in type OUAT Maize Dehusker cum Sheller operated by bullocks in rotary mode

Particulars	Observations	
	No Load	Load
Threshing drum speed, rpm	576	562
Blower shaft speed, rpm	605	595
Air velocity, m/sec	4.6	4.5
Average draft, N	428	456
SOP of bullocks, kmph	1.87	1.84
Power requirement, hp	0.30	0.32
Fatigue score	12	16
Feed rate, kg/h	-	230.5
Output, kg/h (Grain: crop 74%)	-	166.2
Losses, (Broken), %	-	0.84
Losses Unthreshed	-	2.58
Threshing Efficiency, %	-	97.42
Cleaning Efficiency, %	-	92.8
Cost of operation in Maize dehusker cum sheller, Rs/kg		0.55
Cost of operation by Manual dehusking and shelling by tubular maize sheller, Rs/kg	-	6.20

The results on plant growth and yield parameters of different methods of maize cultivation have been presented in Table 7 which indicated that the mechanized maize cultivation method was superior to conventional maize cultivation method in the district with respect to plant height, cob weight, shelling percentage, test weight, no of rows per cob, no of seeds per row, grain yield, stover yield and B:C ratio. The average cost of cultivation and B:C ratio of improved practice were found out to be Rs 33,126.00 per ha and 2.63 as compared to Rs 40,616.00 per ha and 2.08 respectively for conventional practice of maize cultivation (Table 8). The savings in cost of cultivation is Rs. 7490.00 per ha over the conventional practice of maize cultivation. The improved practice of maize cultivation is superior to the conventional practice considering the higher labour requirement, shortage of labour during peak hours, higher drudgery and most importantly higher cost involvement. Considering the plant growth parameters and yield parameters, the mechanised method of maize cultivation is superior to conventional practice.

Table 7: Results on plant growth and yield parameters of different methods of maize cultivation

Treatment details	Plant height, cm	Cob weight, gm	Shelling, %	Test weight (100 grain), g	No of rows/ cob	No of seeds per row	Grain Yield, q/ha	Stover yield, q/ha	B:C ratio
Mechanized maize cultivation	172.3	156.2	77.6	30.5	16.9	28.1	62.34	89.3	2.63
Conventional maize cultivation	167.7	149.7	75.2	29.9	14.6	26.9	60.47	99.3	2.08

Table 8: Cost economics per hectare of maize cultivation

Parameters	Improved Practice	Conventional Practice
Land Preparation Ploughing twice followed by Weed removal & levelling	8 bullock pair per days @ Rs 500=Rs 4000 Weed remover 3 bullock pair days and 6 man days = Rs 3300	10 bullock pair per days @ Rs 500=Rs 5000 14 man days@300/- = Rs 4200
Line sowing	Seed drill 1 bullock pair days = Rs 454	3 bullocks pair days and 6 man days =Rs 3300
Seed	15kg@ Rs 500/kg = Rs7500	15kg@ Rs 500/kg = Rs7500
Fertilizer	LS Rs 4000/-	LS Rs 4000/-
Weedicide	LS Rs 500/-	LS Rs 500/-
Plant protection measures	LS Rs 1500/-	LS Rs 1500/-
Intercultural operation and fertilizer top dressing	Fertilizer applicator cum ridger –3 bullock pair days Rs1386	Manual hill dropping and deshi plough ridging 5 bullock pair days and 5 man days– Rs 4000
Harvesting	Harvesting-Rs 5000	Harvesting-Rs 5000
Threshing	Dehusking & shelling- 6 bullock pair days and 6 mandays Rs 0.88/kg Rs 5486/- for 62.34q	Dehusking 12 mandays per ha (60.47q) – Rs 3600 Power thresher 1.99 hrs by tractor operated sheller @ Rs1000/h and 30q/h capacity = Rs2016/-
Total cost of cultivation, Rs/ha	33,126	40,616
Crop Yield, q/ha	62.34	60.47
B:C ratio	2.63	2.08
Saving in cost, Rs/ha		7490/-

Conclusion

The use of improved bullock drawn agricultural implements in maize cultivation, developed through the AICRP on UAE was proved to be economically beneficial to the small and marginal farmers of the district apart from reduction in drudgery, labour requirement. These implements need to be commercialized and made available to the farmers of the district and state on subsidy. With increase in utilization of animal energy for maize cultivation, the annual use of the bullocks can be enhanced which will reduce the burden of maintenance cost the bullocks by the small and marginal farmers. Promotion of animal drawn implements further facilitates the sustainability of animal energy, of late considered as green energy, clean energy as well.

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