



Feasibility Evaluation of Animal Drawn Improved Equipment under Terrace Cultivation- A Case Study in Sikkim

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ABSTRACT:

More than 64% of the population is dependent on agriculture and related activities. In country, there are 80 % operational holdings in small and marginal categories which depend fully on animal power. Around 75 million ha (55% of the total cultivated area) of the country is managed by draught animals with 1.5-2 ha command area. The present use of draught animals is limited from 100 to 120 h per year in cultivation operation. It has been reported that the total area under food crop production in Sikkim was 81320 ha (HRD report, Govt. of Sikkim; 2005-06). The command area per hectare by use of traditional equipment was 1 ha (50-70 terraces). The command area by use of improved equipment could be increased up to 1.5 ha (80-100 terraces). The animal based cultivation is treated as zero based system as the animals are well maintained and sustained in the hills eco-system of Sikkim cost effectively. For mustard and wheat crops, seedbed preparation and seeding equipment were feasibility tested in terrace cultivation and the cost economics was compared over traditional practices. The effective field capacity and cost of operation of improved wing plough were 0.024 sq.m/h and Rs. 1600/ ha for puddling operation in rice production system under terrace farming. The improved wing plough provided output from 200 to 300 sq.m/h for dry tillage operation. Under seeding equipment, single row seed drill was tested for mustard and wheat which gave effective field capacity varying from 300 to 500 sq.m/h. The single row seed drill when used for zero tillage seeding, the effective field capacity was 300 sq.m/h. The savings in cost of operation and time were 65% and 69% respectively over traditional method.



INTRODUCTION

In Sikkim state 40.04 % rural population is below poverty line. The agriculture in Sikkim is mixed type and at subsistence level. Bullocks are the major source of farm power (43000 number: 2003). The total villages (450 no.) coming under 176 *gram panchayats* are dependent upon animal based farming utilizing 58700 bullocks (Tiwari and Rautaray, 2011). The average annual utilization of animal power (43 days) is limited to tillage operation in all the four districts (Gangtok, Namchi, Gyalshing and Mangan). Most of the cultivation is done either in sloping fields or in narrow terraces. The average land holding size is 1.94 ha and net irrigated area is 11300 ha. Fifty percent farmers prefer custom hiring of bullocks for field preparation. Farmers are using traditional plough, yoke *dande* leveler), sickle and mud bin. The animal drawn clod crusher-leveler-planker equipment (size : 750 mm, weight : 18.5 kg, unit price : Rs. 4500) performed four operations (breaking of clods, leveling, planking and puddling). Three ground wheels were provided for transporting on approach roads. It gave effective field capacity of 0.065 ha/h (Pandey and Tiwari, 2004). Bullock drawn three row seed cum fertilizer drill consisted of six vertical rotor type metering device three for seed metering and three for fertilizer metering. The machine of 55 kg weight gave effective field capacity of 0.11-0.13 ha/h for kodo and little millet. The metering with vertical rotor ensured 70% seed saving over traditional broadcasting. The cost of operation varied Rs 500-600/ha (Pandey *et al.*, 2004). CIAE Bhopal developed two row animal drawn seed drill (Mahakal) using agitator and orifice for seed metering inside the seed box. This equipment provided work rate of 0.10 ha/h. The mustard seeds metering using fluted roller of 2x2 mm flute size was employed on seeding attachment fitted on CIAE design multi-purpose tool frame. The seeding attachment showed work rate of 1200 sq. m/h (Pandey *et al.*, 2005). Animal drawn two row inclined plate planter was developed and tested for mustard in black cotton soils at CIAE, Bhopal which had effective field capacity of 0.14 ha/h (Pandey and Tiwari, 2004). The wooden vertical rotor with cells on periphery was provided on two row seeding equipment developed at CIAE Bhopal which showed work rate of 1000 sq.m/h for sowing mustard (Pandey *et al.*, 2006). Acharya N.G.Ranga University, Hyderabad developed two row seed cum fertilizer drill employing rotor for metering different crops seeds. For mustard, the equipment provided effective field capacity of 0.15 ha/h (Pandey *et al.*, 2008).



CIAE Bhopal developed two row animal drawn seed drill (Mahakal) using agitator and orifice for seed metering inside the seed box. This equipment provided work rate of 0.10 ha/. The mustard seeds metering using fluted roller (flute size : 2x2 mm) was employed on seeding attachment fitted on CIAE design multi-purpose tool frame. The seeding attachment showed work rate of 1200 sq. m/h (Singh *et al.*, 1996).

The objective of comparative evaluation of improved improved equipment is to help Department of Agriculture, Government of Sikkim for finalizing subsidized, cost effective equipment which may be adopted for promoting line sowing of crops replacing present practice of manual hand broadcasting of costly seeds followed by leveling using traditional wooden leveler (*Dande*) for partial covering of seeds under terrace condition.

MATERIALS AND METHODS

The feasibility testing of different improved equipment for accomplishing unit operations were conducted to achieve saving in time and labour. The improved equipment suitable in terrace cultivation were identified and modified through their reduction in weight and size to achieve inputs saving and more yield in hills. The improved plough and single row seed drill were tested in terrace cultivation for wheat and mustard for normal sowing. After paddy harvest, the use of zero tillage seeding system was also tested for sowing of wheat and its yield was at par over traditional sowing method.

Four improved equipment were evaluated in terrace cultivation which included CAEPHT animal drawn improved wing plough, AAU iron plough, animal drawn single row seed drill for mustard and wheat and animal drawn single row zero till drill.

On Farm test trial of improved wing plough on terrace (14x3.3 m) was organized for puddling operation in Kumrek-Bhasme village in East Sikkim (Fig. 1). The wet tillage operations using improved wing plough and conventional plough were performed in two terraces (table 1). The pull required by improved wing plough was lesser and gave better shallow puddling over conventional plough. The speed of operation of conventional plough and improved wing plough were 2.1 and 2.25 km/h respectively sections.

The animal drawn seed drill for mustard crop (Fig. 2) incorporating fluted roller metering mechanism was modified. The machine field trial was conducted in an area of 429 sq.m at



Samlik- Marchak. The crop was sown at row spacing of 300 mm and depth of planting of 30 mm. The field capacity of machine was 0.051 ha/h at speed of operation of 2.88 km/h. The seed rate obtained was 9.32 kg/ha prevailing under terrace condition for mustard seed in Sikkim. The detail specification and performance results of machine are given in table 2.

The tillage was performed at Samlik village of East Sikkim using improved iron plough after harvest of rice on terrace (tables 3). The soil moisture content (d.b), size of terrace, straw density/m² prior to ploughing were noted. The other parameters recorded were speed of bullock, depth of operation, working width of plough, time loss at head land, draft of the plough during ploughing, total duration of test.

The normal sowing of wheat after harvesting of rice was performed by broadcasting method after accomplishing tillage operation (twice) using conventional plough in Sikkim. The paddy straw stubbles are mixed properly and wooden *pata* was employed for smoothing land surface. The single row seed drill which was used earlier for mustard sowing was identified for normal sowing of wheat after removing mustard orifice plate fitted inside the seed hopper. Under laboratory test, machine was tested for uniformity of distribution of seeds in the row seed calibrations of the unit before trial in the field. The field observations were noted during the sowing operation which included quantity of seeds used total duration of test, soil moisture, depth of sowing, speed of travel, draft and size of terrace. The zero tillage system (Fig.3) was incorporated in animal drawn single row seed drill by providing inverted T furrow opener (size 160 mm). The machine was tested on low terrace. The soil moisture and paddy stubbles/m² were noted. The speed of travel, size of terrace, depth of sowing and quantity of seeds used were also recorded. The details of trials are given in table 5. Due to performing tillage operation normal was performed the sowing by one week late.

One animal drawn improved seed drill and one conventional equipment (*Dande* i.e leveler) were evaluated for seedbed preparation followed by sowing operation for wheat crop in terrace condition after harvest of rice at Samlik Marchak village in east Sikkim. For seed bed preparation AAU animal drawn iron plough (150 mm size) and improved iron plough



(200 mm size) were used in previous operations. The seedbed preparation using improved plough was followed by animal drawn conventional leveler (*Dande* of 15 kg weight and 914 mm width) for smoothening the surface. The field test trials of conventional leveler were conducted in two terraces 44.2 m length and 2.15m and second of 35 m length and 2.58 m width respectively. The field capacities of animal drawn leveler were 0.01 and 0.054 ha/h corresponding to terrace area of 139.23 and 90.3 sq.m. Similarly the field efficiencies were 88% and 89.6% respectively for the terraces of having 139.23 and 90.3 sq.m areas. The speed of operation during field trials of leveling using *dande* were 2.65 and 3.78 km/h corresponding to the terrace length of 44.2 and 35 m (Tables 6).

Animal drawn improved single row seed drill (which was tested for mustard after modification) was tested for wheat (PB-343) in terrace for normal sowing at Samlik Marchak in East Sikkim. The size of the terrace was 35 m in length and 2.58 m in width. The area of terrace and soil moisture (d.b) was 90.3 sq.m and 18.1% respectively. The average time in covering one terrace was 39 sec. At speed of operation of 3.23 km/h, the field capacity was 0.0318 ha/h corresponding to field efficiency of 68.9%. The average depth of operation was 76.4 mm and the average row spacing was 228 mm. The results are given in table 7.

In another terrace (size 44.2 x 3.15 m) the broadcasting practice for sowing wheat was followed after animal drawn improved iron plough and conventional leveler (*dande*) twice each. After broadcasting one operation of leveler (*dande*) was accomplished for proper covering of seeds which took 9 min in covering 139.23 sq.m terrace. The average speed of operation was 2.65 km/h. The field capacity and field efficiency were 0.092 ha/h and 87.4 % respectively during leveling using *dande*.

RESULTS AND DISCUSSION

The table 1 indicated that field capacity (0.024 ha/h) of improved iron plough is higher due to more working width. The cost of operation of animal drawn improved iron plough is Rs. 1600/ha as compared to traditional plough cost of operation of Rs.1990/ha.

As mentioned in table 2, the effective field capacity and cost of operation for mustard sowing using animal drawn seed drill were 0.051 ha/h and Rs. 330 ha/h respectively. The crop was sown at row spacing of 300 mm and depth of planting of 30 mm. The machine was



operated at speed of operation of 2.88 km/h and observed seed rate obtained was 9.32 kg/ha. The net saving over traditional sowing practice (broad casting) was Rs.770/ha. The tables 3 and 4 revealed that field capacity and cost of operation of improved iron plough and AAU MB plough were 0.03 and 0.021 ha/h respectively. The net savings in operation with improved iron plough were Rs. 176/ha and Rs.680/ha over AAU MB plough and traditional plough respectively. The zero till drill field capacity varied 0.028-0.03 ha/ha (table 5). The saving in cost of operation and time were 65% and 69% respectively over traditional method (traditional plough twice and leveler single operation and broadcasting of seed). The plant population of wheat crop sown using zero till seed drill varied 200-230 per sq. meter.

For wheat sowing under normal condition, the field capacity was 0.0318 ha/h corresponding to field efficiency of 68.9%. at speed of operation of 3.23 km/h, The average depth of operation was 76.4 mm and the average row spacing was 228 mm.

The field capacity of traditional animal drawn leveler (*dande*) varied 0.041-0.054 ha/h (tables 6). As indicated in table 7, the single row animal drawn seed drill gave field capacity of 0.031 ha/h for wheat sowing and the cost of operation was Rs.436/ha. The seed broadcasting trial for wheat was conducted in 139.23 sq.m area and the effective field capacity in broadcasting was 0.0278 ha/h corresponding to field efficiency of 92.8% respectively.

CONCLUSIONS

- i. The animal drawn improved iron plough, animal drawn single row seed drill for mustard and wheat and animal drawn single row zero till drill gave satisfactorily results over traditional practices in terrace cultivation of Sikkim.
- ii. Under terraces cultivation improved plough modified at CAEPHT (8 kg weight & 200 mm size) showed better performance over AAU improved plough and traditional plough used at Sikkim.
- i. For mustard sowing single row animal drawn seed drill was found efficient (field capacity, 0.05 ha/h) over traditional sowing method.



- ii. The wheat sown using zero till drill (single row) provided savings of 65 and 69 % in cost of operation and time over normal sowing by traditional practice in Sikkim. The field capacity of the zero till drill varied 0.028-0.03 ha/h.

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Tab.1 Field test of animal drawn improved wing plough for puddling operation.

Location : Kumrek-Bhasme

Particular	Values	
	Improved wing plough	Traditional (wooden) plough
Size of terrace, m	14x3.3	14x3.3
Working width, mm	200	100
Depth of puddling, mm	100	165
Speed of operation, km/h	2.25	2.1
Field capacity, ha/h	0.024	0.01
Field efficiency, %	53.6	52
Cost of operation, Rs/ha	1600	1990

Table.2 Testing of animal drawn seed drill for sowing of mustard

Location : Samlik-Marchak village, East-Sikkim

Particulars	Values
Overall dimension (lxbxh), mm	940x480x730
Weight of machine, kg	22.1
Shape of hopper	Trapezoidal
Seed metering mechanism	Fluted roller
Size of orifice, mm	5.5
Furrow opener	
Number	One
Size, mm	180
Type	Shoe
Width of machine, mm	480
Hopper size	
Top width, mm	220
Bottom width, mm	150
Height, mm	165
Length, mm	300
Capacity, kg	9.15



Drive wheel diameter, mm	430
Transport wheel diameter, mm	260
Performance test	
Field test	
Total duration of test, h	0.83
Total quantity of mustard seed used, kg	0.4
Soil moisture content (d.b), %	21.6
Bullocks speed (under field), km/h	02
Draft, kg	40
Area covered, sq.m	429
Row spacing, mm	300
Field capacity, ha/h	0.05
Field efficiency, %	52
Plant emergence, %	91.66

Table 3 Field testing of improved iron plough

Village: Samlik-Marchak (East-Sikkim)

Parameters	Values
Previous crop grown	Paddy (sickle harvested)
Total duration of test, min	50
Av no of stubbles/sq.m	18
Size of field, sq.m	139.23
Length of terrace, m	44.2
Width of terrace, m	3.15
Soil moisture (d.b), %	20.2
Working width, mm	200
Depth of ploughing, mm	100
Draft, kg	46.5
Field capacity, ha/h	0.03
Field efficiency,%	51.8



Table 4 Field testing of AAU Animal drawn MB plough.

Village: Samlik (East-Sikkim)

Parameters	Values
Total duration, min	25
Terrace length, m	35
Width of terrace, m	2.58
Area of terrace, sq, m	90.3
Working width, mm	150
Depth of operation, mm	95
Av. speed of operation, km per/h	2.75
Draft, kg	44.8
Field capacity, ha/h	0.021
Field efficiency, %	50.11

Table 5 Field testing of zero-till seed drill.

Village : Samlik (East-Sikkim)

Crop : Wheat (variety- PBW 343)

Parameters	Values	
	1 st Trial	2 nd Trial
Previous crop	Rice	Rice
Total duration of test, min	25	20
Area of terrace (m ²)	127.5	94.97
Length of terrace, m	46.2	42.4
Width of terrace, m	2.76	2.24
Average no of stubbles, sq.m	18.8	18.66
Height of stubbles, mm	85	92
Soil moisture (d.b), %	21.2	20.6
Depth of sowing, mm	60	70
Row spacing, mm	228	228
Bullock speed, km/h	1.93	2.7
Draft, kg	48.3	50.7
Field capacity, ha/h	0.03	0.028
Field efficiency, %	69.70	46.50



Table 6 Field test of animal drawn clod crusher cum planker (*Dande*)

Village : Samlik Marchak

Particulars	First trial	Second trial
Specification		
Overall dimension (lxbxh,) mm	914x152.4x152.4	914x152.4x152.4
Weight of dande, kg	15	15
Field test		
Previous crop grown	Rice	Rice
Previous operation	Ploughing using improved iron plough	Ploughing using improved iron plough
Total duration, min	20	10
Length of Terrace, m	44.2	35
Width of Terrace,m	3.15	2.58
Size of field, sq.m	139.23	90.3
Working width, mm	914	914
Soil moisture (d.b), %:	19.65	18
Average operating speed, m/sec	0.736	1.05
Field capacity, ha/h	0.0417	0.054
Field efficiency,%:	88	89.6
Mean weight diameter of clods prior to operation, mm	100	112
MWD of clods after operation, mm	28	33
Clod crushing index, %	78	70.5

Table 7 Field test of Animal drawn single row seed drill for wheat

Village : Samlik Marchak

Parameters	Values
Previous crop	Rice
Previous operation	Improved iron plough (2 times) & Dande (2 times)
Total duration, min	17
Length of terrace, m	35
Width of terrace, m	2.58
Area of terrace, sq.m	90.3
Soil moisture (dry basis), %	18.1
Working width, mm	228
Depth of operation, mm	76.4
Average speed of operation, m/sec	0.897
Field capacity, ha/h	0.0318
Field efficiency,%	68.9



Fig.1. Improved wing plough in operation



Fig. 2. Single row seed drill for mustard



Fig. 3. Single row zero till-seed drill for wheat



Fig. 4. Wheat germination after zero tillage Sowing condition