

# Operator physiological response and bullock draughtability during primary tillage

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**Abstract:** A study on draughtability of small sized bullocks (Pair weight of 430 kg) of Kumaon hills of Uttarakhand, India for operating primary tillage by a newly developed VL Syahi hal (plough) was conducted at ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora in five different locations of Almora and Bageshwar district of Uttarakhand in the winter season, 2012 (November and December month). The physiological responses like pulse and respiration rate in ploughing with VL Syahi hal have increased with duration at the rate of sharp increase in the first hour followed by slow increase thereafter. The pulse and respiration rate increased by 27% and 14% respectively from its initial value after 1st hour of work. The average draft requirement of VL Syahi hal was observed to be within draughtability of the small bullocks. The bullocks could sustain the ploughing load (11.86% of their body weight) for two hours of continuous working during winter period. The average field capacity was 0.023 ha/h (43 h/ha) compared to 0.0136 ha/h (73 h/ha) with traditional plough. Considering draught, fatigue score, field capacity and soil pulverization, VL Syahi hal of 180 mm width was found to be suitable for small size bullocks of Kumaon hills of Uttarakhand.

**Keywords:** Draughtability, Physiological responses, Fatigue score, VL Syahi hal, Traditional hal

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## 1 Introduction

Uttarakhand situated in North Western Himalayas of India lies between 28°43'N to 31° 27' N latitude and 77°34' E to 81° 02' E longitude falls under Western Himalayan Region (agro-climatic zone-I). The total geographical area of the state is 53,48,300 hectare, of which 86% is under hills with forests covers close to two-thirds of the area and 13% under agriculture. The average land holding in Uttarakhand is 0.95 ha (0.82 ha in hills) in comparison to national average of 1.32 ha. In the state, cattle accounts for 1.12% (2.23 million) of the total cattle population of the country generating about 1.1 million hp of power considering 0.5 hp generated by each animal.

Draughtability of an animal is defined as its sustainable pulling capacity with optimum draft and speed without fatigue. The bullocks of the hilly region of Uttarakhand are mostly under small in size with body weight of a pair ranging from 350 to 500 kg. It is often observed that the bullock drawn implements available commercially in India need a draft above the draught capacity of the local bullocks in the region resulting in non adoption of these implements by the farmers. The farmers dependent on bullocks are left with none other option than using the traditional implements that resulted in low output and increased cost of operation (Singh, 2014). The draught capacity of local bullocks needs to be assessed for proper design and development of implements for their adoption by the farmers (Dhakane et al., 2010). The work output (draughtability) of the animal depends upon the breed, physical condition, harnessing device, loading characteristics, rate and duration of work output,

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environment, feed and feeding method. This is assessed by measuring the draught, speed and physiological responses of the animals (Din, 2000; Behera et al., 2006).

In Uttarakhand, majority of the farmers are under small and marginal categories and draught animals are the major source of farm power. Hill farmers are generally using wooden hal which is being made by cutting different locally available tress like Banjh, Utish etc. that requires frequent repair due to poor durability in addition to creating adverse environmental impact. Keeping all these limitations in mind, a complete metallic VL Syahi hal (11kg) was designed and developed and its draughtability for small sized bullocks was assessed with the objectives of studying the physiological responses, distress symptoms, fatigue level for sustained work along with overall performance of ploughing.

## 2 Materials and methods

The experiment for draughtability study of small sized bullocks (non-descript breed of bullocks of Kumaon hills of Uttarakhand) was conducted at five different locations in Almora and Bageshwar district of Uttarakhand in the winter 2012 (November and December month) using VL Syahi hal. The plough was tested in the field having initial moisture content of 16-18.0% and bulk density of 1.38-1.41 g/cm<sup>3</sup>. The ambient temperature and relative humidity ranged from 16<sup>o</sup>C –18<sup>o</sup>C and 74%-78%, respectively during the experiment. The VL Syahi hal of 18 cm width and 11 kg

of weight along with traditional hal of 14 cm width and 18 kg weight were used in the tests (Figure 1). The physiological parameters of bullocks and operator were recorded periodically along with physical behavioural symptoms of bullocks measured at one hour interval for three hours. The small sized bullocks pair having 430 kg weight was used for the study. The independent parameters i.e. depth of ploughing was kept constant at 100 mm. The dependent variables viz. (a) Physiological responses, i.e. Pulse rate (PR), Respiration rate (RR) and Body temperature (BT); (b) Distress Symptoms i.e. Frothing, Leg non-coordination, Excitement, Inhibition to progressive movement and Tongue protrusion; (c) Fatigue Score; (d) Operating Speed and (e) Power output were recorded and analysed. The pulse rate was measured with the help of a stethoscope and was expressed as beats per minute (bpm). The respiration rate was determined by counting the number of blows of expired air per minute (bpm) at the nostril on the back side of the palm. The body temperature was recorded by a clinical thermometer. Energy expenditure rate of male operators was estimated from the heart rate response using the equation (Yadav et al., 2007) as given below for Indian male agricultural workers.

Energy expenditure rate (Kcal/min) =

$$\frac{HR(\text{beats / min}) - 66}{2.4 \times 4.187}$$



(a)



(b)

Figure 1 Bullock Drawn VL Syahi hal (a) and local hal (b) used for study

The distress symptoms were observed visually. The fatigue level of the bullocks was determined by using the fatigue scorecard developed by Upadhaya and Madan (1985). Maximum score in the scorecard is 40. A bullock is considered to be fatigued, if the score reaches 20. The soil moisture, bulk density & other performance parameters such as draft, speed, capacity etc. were measured as per standard procedures. The draft requirement was measured and its equivalence in percentage bodyweight was determined. The draft was measured by a spring dynamometer of 100 kg capacity with least count of 2 kg. The speed of the bullocks was measured by taking the time to cover 20 meters distance.

Ten observations were taken at different period within one hour to determine the average speed for one hour duration. The power output was estimated by using the Equation (1) (Ghosal et. al., 2015) as given below:

$$\text{Power} = D \times S \times 0.001 \quad (1)$$

Where,  $D$ =Draft in N;  $S$  = Speed in m/s and  $power$  in kW

Soil inversion was measured by the weed count method. A square ring (30x30 cm) was placed at random in the field before starting the test. The number of weeds and stubbles enclosed within this ring were counted at different places in test plot. The above process was repeated after ploughing the field and data was recorded. See Equation (2):

$$\text{Soil inversion, \%} = \frac{(\text{No. of weeds before test} - \text{No. of weeds after test}) \times 100}{\text{No. of weeds before test}} \quad (2)$$

VL Syahi hal was also compared with local hal for its feasibility in hills in respect of power output, cost of operation and performance.

### 3 Results and discussion

The variations in physiological responses of operator (40 years old) and bullocks (6-6.5 years old) during ploughing are given in Table 1. The plough was tested at a constant depth of 100 mm in the field. The physiological responses of bullocks and operator were taken at 1h interval up to 3h. It was observed that the operator's pulse rate increased from 67 to 74 beats/min during 1<sup>st</sup> hour and then increased by 9.4% and 11% over previous hour of operation using VL Syahi hal, whereas it increased by 13% and 15% over previous hours of operation using local hal. The energy expenditure rate of the operator also increased 86% and 60% with VL Syahi hal and 101% and 65% with Local hal over previous hours of operation. The lesser increase in the pulse rate and energy expenditure rate of operator in case of VL Syahi hal might be due to very less efforts required to operate the plough whereas in local hal, the operator has

to apply more vertical force on the handle to facilitate proper penetration of the plough in the soil. Further, the weight of VL Syahi hal is about 39% less than Local hal due to which it was easy to handle the plough for the operator during turning. The pulse rate, respiration rate and body temperature of bullocks increased in the range of 65-73 beats/min, 24-34 breaths/min and 38.4°C -38.6°C after 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> hours of operation from their resting values of 51 beats/min, 21 breaths/min and 38.3°C, respectively with VL Syahi hal whereas with local hal it is increased in the range of 70-84 beats/min, 30-48 breaths/min and 38.9°C -39.1°C after 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> hours of operation. The increase in pulse rate (27%-37%) and respiration rate (13%-43%) of bullocks was at a faster rate in the 1<sup>st</sup> hour and subsequently the rise was at a decreasing rate over the previous hours of work for both the VL Syahi hal and Local hal. However, the increase in Pulse rate and respiration rate in Local hal was higher and this might be due to the higher draught level of 13.25% of the bodyweight.

**Table 1 Effect of ploughing using different hal types on physiological response of operator and bullocks**

Particulars	Initial	1 <sup>st</sup> hour		2 <sup>nd</sup> hour			3 <sup>rd</sup> hour		
		VL Syahi hal	Local hal	VL hal	Syahi	Local hal	VL hal	Syahi	Local hal
<b>Operator</b>									
Pulse rate, beats/min	67	74	76	81	86	90	99		
Respiration rate, breaths/min	20	26	28	31	35	35	44		
Energy expenditure rate, J/min	414.4	3349.4	3768.1	6238.3	8331.7	9964.5	13732.7		
<b>Bullocks</b>									
Pulse rate, beats/min	51	65	70	68	77	73	84		
Respiration rate, breaths/min	21	24	30	29	39	34	48		
Body temperature, °C	38.3	38.4	38.9	38.9	39.1	39.1	39.1		
Fatigue score	-	16	18	18	22	21	25		

The field performance results of VL Syahi hal and local hal are presented in Table 2. The average draft was observed 510 N and 580 N with VL Syahi hal and local hal, respectively which was 11.86% and 13.48% of the body weight of the small sized of hilly bullocks. Due to speed reduction after 1<sup>st</sup> and 2<sup>nd</sup> hour of operation, the effective field capacity of VL Syahi hal reduced from 0.029 ha/h during 1<sup>st</sup> hour to 0.017 ha/h in 3<sup>rd</sup> hour of operation whereas the same using local hal was 0.019 ha/h during 1<sup>st</sup> hour and reduced to 0.008 ha/h in 3<sup>rd</sup> hour of operation. So, the mean area coverage was 0.023 ha/h (43 h/ha) with VL Syahi hal and 0.0136 ha/h (73 h/ha)

with local hal, thereby resulting in 41% increase in area covered by VL Syahi hal. The soil inversion percentage was observed more with VL Syahi hal (56%-59%) than local hal (46%-50%) may be due to more width of operation of VL Syahi hal. The average cost of operation of ploughing for one hectare area with VL Syahi hal (Rs.1,800/-) was found 46% less than local hal (Rs. 3,320/-). The fatigue behavior symptoms of bullocks (Table 3) were observed that the leg un-coordination and inhibition of forward movement appeared after 1<sup>st</sup> of operation in local hal and after 2<sup>nd</sup> hour of operation in VL Syahi hal.

**Table 2 Effect of ploughing using different hal types on some field performance parameters**

Parameter	Average value					
	1 <sup>st</sup> hour working		2 <sup>nd</sup> hour working		3 <sup>rd</sup> hour working	
	VL Syahi hal	Local hal	VL Syahi hal	Local hal	VL Syahi hal	Local hal
Draft, N	510	580	500	580	510	580
Moisture content, %	16-18.0		16-18.0		16-18.0	
Bulk density, g/cm <sup>3</sup>	1.38-1.41		1.38-1.41		1.38-1.41	
Speed of operation, km/h	2.0	1.7	1.74	1.4	1.3	0.9
Power output, kW	0.285	0.276	0.25	0.23	0.185	0.15
Effective width, cm	18	14	18	14	18	14
Effective field capacity, ha/h	0.029	0.019	0.024	0.014	0.017	0.008
Field efficiency, %	81	80	77	71	73	63
Labour requirement, man-h/ha	34	53	42	71	59	125
Soil inversion,%	50	48	48	45	58	46
Cost of operation, Rs/ha	1360	2120	1680	2840	2360	5000

**Table 3 Fatigue behavioral symptoms of bullocks**

Particulars	1 <sup>st</sup> hour		2 <sup>nd</sup> hour		3 <sup>rd</sup> hour	
	VL Syahi hal	Local hal	VL Syahi hal	Local hal	VL Syahi hal	Local hal
Frothing	No	No	No	Start	Yes	Yes
Inhibition of progressive movement	No	No	No	Start	Yes	Yes
Leg un-coordination	No	No	Start	Yes	Yes	Yes
Excitement	No	No	No	Start	Start	Yes
Tongue protrusion	No	No	No	Start	start	Yes
Fatigue score	16	18	18	22	21	25

The power output decreased and fatigue score increased with duration of ploughing (Figure 2). The bullocks got fatigued during 3<sup>rd</sup> hour while ploughing with VL Syahi hal with a fatigue score of 21 whereas the score of 22 was with local hal during 2<sup>nd</sup> hour. This indicated that small size bullocks were able to pull 11.86% of their body weight during winter season without being fatigue for ploughing with VL Syahi hal for two hours. Allowing for a rest of 10 minutes after two

hour of work, the fatigue score was calculated to be 21 during 3<sup>rd</sup> hour of work. It therefore clearly indicated that the small size bullocks were capable of working with VL Syahi hal continuously for two hours without getting fatigued whereas in case of local hal, fatigue score of 22 was observed during 2<sup>nd</sup> hour of work and rest of 10 minutes thereafter, the fatigue score of 25 was calculated after 3<sup>rd</sup> hour of ploughing.

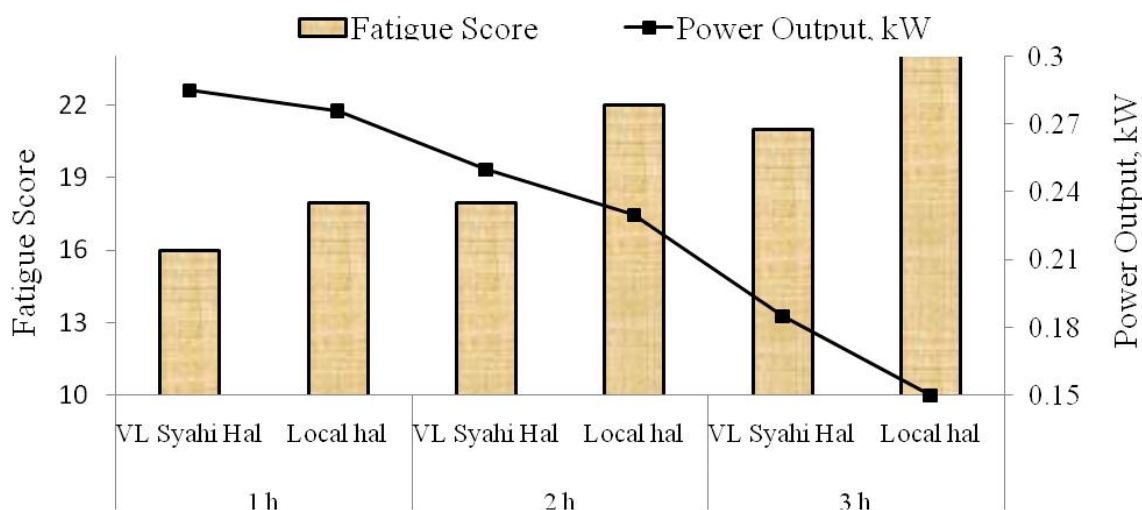


Figure 2 Response of fatigue score and power output of bullocks in VL Syahi and local hal

**4 Conclusions**

The increase in pulse rate (27%-37%) and respiration rate (13%-43%) of bullocks was at a faster rate in the 1<sup>st</sup> hour and subsequently the rise was at a decreasing rate over the preceding hours of work in case of both VL Syahi hal and local hal. The small size bullocks were able to pull 11.86% of their body weight without being fatigued for ploughing with VL Syahi hal

for two hours and mean power output was 0.24 kW. The mean area coverage (0.023 ha/h) by VL Syahi hal was 41% more than the local hal. The soil inversion percentage was observed more with VL Syahi hal than local hal. Hence, animal drawn VL Syahi hal was recommended as a good alternative for small sized bullocks working in hills than traditional local hal for tillage operation for better draughtability and higher efficiency.

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