OPTIMUM HANDLE HEIGHT FOR AN ANIMAL-DRAWN BLADE HARROW

L. P. Gite

Central Institute of Agricultural Engineering,
Nabibagh, Berasia Road, Bhopal, 462 018, India

A blade harrow is a tillage implement commonly used by the farmers of Central and Western India. The handle is one of the main components of a blade harrow and its height has an influence on operator's comfort as well as work performance. Therefore, this study was carried out to determine the optimum handle height for an animal-drawn blade harrow. Two experiments were conducted with four male subjects to study postural discomfort and physiological reactions separately at six handle heights. Downward force applied by the operator on handle, and depth and speed of operation were also recorded. The lowest postural discomfort was noticed at handle height equal to 1.0 metacarpale III height. Here, the overall discomfort rating was 2.4 on an eight point psychophysical rating scale (0 = no discomfort, 7 = extreme discomfort) and the body part discomfort score was 16.3 (the maximum being 53.8 at working height equal to 1.6 metacarpale III height). The mean heart rate and oxygen consumption at this handle height were 103.9 beats/min and 0.536 l/min, respectively. Considering the data of postural discomfort and also of heart rate and oxygen consumption, the optimum handle height for the animal-drawn blade harrow worked out to be equal to 1.0 metacarpale III height, i.e. 637 to 732 mm (5th and 95th percentile values respectively, of metacarpale III height of Indian agricultural workers).

A blade harrow (Bakhar) is a tillage implement commonly used by the Indian farmers in clayey soil region for seed bed preparation. It consists of a frame (wooden cross beam), two tines, a blade, a beam and a handle. The implement is hitched to a yoke through the beam. The operator holds the reins of bullocks in one hand and controls the operation through the handle with other hand. Depending upon the field situation, the operator applies downward force on the handle to get
the desired depth of operation. The height of handle* has an effect on the operator’s comfort as well as work performance. Therefore, proper handle height is necessary for efficient operation. As per the recommendation of Bureau of Indian Standards (BIS, 1979), the height of handle of animal-drawn blade harrow should be adjustable between 800 and 1,100 mm. However, no objective data is available to support this recommendation. Therefore, this study was undertaken to generate such data and to determine the optimum handle height for an animal-drawn blade harrow.

Blade harrow is a traditional implement. ICAR (1960) reported details about nine different types of blade harrow being used in the country. No specific mention has been made of handle height, but figures show the handle height between 600 to 900 mm. In traditional blade harrows, the handle is made of wood and generally the operator makes his own adjustment according to his requirement. However, in improved blade harrows, the handle as well as frame are made of steel; therefore, the scope of adjustment is provided at the time of fabrication itself.

METHODS

Two experiments were conducted separately: one for studying physiological reactions and another to assess postural discomfort (four male subjects). All the subjects were well acquainted with handling of bullocks and blade harrow operation. Their mean age, stature, metacarpale III height** and weight were 38.3±5.2 years, 161.8±4.6 cm, 66.6±1.9 cm and 49.5±4.0 kg, respectively. A traditional blade harrow having 500 mm blade width and weighing 40 kg was used for the experiment. A handle having provision for variation of grip height was fabricated and used in the experiment. Six handle heights (Table 1) varying from 0.8 MH** to 1.60 MH of the subject were studied. For heart rate measurement, UNI-INSTA (India) ECG telemetry system having 30 m range was used whereas oxygen uptake was measured using Morgan Oxylog (U.K.) (Fig. 1). Downward force applied by the operator in the line of handle was measured by using a Novatech load cell (50 kgf capacity) with digital indicator (Fig. 2). The overall body discomfort was measured on an eight point psychophysical rating scale (0 = no discomfort, 7 = extreme discomfort) using the adapted CORLETT and BISHOP (1976) scale (Yu and KEYSERLING, 1989). The localized discomfort was assessed in 23 body regions using the modified CORLETT and BISHOP (1976) technique (LEG and MAHANTY, 1985). Quality of harrowing operation was measured in terms of depth and speed of operation. The physiological trials were of 10-min duration whereas the postural discomfort trials were of 30-min duration. Rests of 10- and 15-min duration.

* Handle height: The vertical distance between ground and the center of handle grip when the harrow is set in its working position.

** Metacarpale III height: MH: It is the height of the knuckle (from ground level) where the middle finger joins the palm. It is generally equal to grip height in standing posture.
Table 1. Physiological responses of the subjects and parameters of harrowing operation at different handle heights (Experiment 1).

<table>
<thead>
<tr>
<th>Handle height Notation</th>
<th>Heart rate (HR) beats/min</th>
<th>Oxygen uptake ( \left( V_{O_2} \right) )/min (STPD)</th>
<th>Force applied on handle N</th>
<th>Depth of operation mm</th>
<th>Speed of operation km/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>H_1 0.85 MH</td>
<td>109.1</td>
<td>0.510</td>
<td>98</td>
<td>90</td>
<td>1.79</td>
</tr>
<tr>
<td>H_2 1.00 MH</td>
<td>103.9</td>
<td>0.536</td>
<td>86</td>
<td>92</td>
<td>1.75</td>
</tr>
<tr>
<td>H_3 1.15 MH</td>
<td>108.9</td>
<td>0.595</td>
<td>77</td>
<td>91</td>
<td>1.48</td>
</tr>
<tr>
<td>H_4 1.30 MH</td>
<td>107.6</td>
<td>0.533</td>
<td>57</td>
<td>81</td>
<td>1.64</td>
</tr>
<tr>
<td>H_5 1.45 MH</td>
<td>105.6</td>
<td>0.481</td>
<td>64</td>
<td>78</td>
<td>1.43</td>
</tr>
<tr>
<td>H_6 1.60 MH</td>
<td>105.5</td>
<td>0.605</td>
<td>50</td>
<td>67</td>
<td>1.21</td>
</tr>
</tbody>
</table>

\[ F_{(5,15)} \] 0.919 \hspace{1cm} 1.83 \hspace{1cm} 13.37 \hspace{1cm} 9.40 \hspace{1cm} 1.92
Significant at \( p < \) 0.5 \hspace{1cm} 0.25 \hspace{1cm} 0.001 \hspace{1cm} 0.001 \hspace{1cm} 0.25

Fig. 1. Measurement of heart rate and oxygen consumption of the operator during operation.

respectively, were given in these trials. Sequence of treatments was decided at random in both of these trials. The data were analyzed with a single factor repeated measures analysis of variance (Winer, 1971). The multiple t-test technique (Raghavarao, 1983) was used to probe significance amongst treatment means.

RESULTS

Table 1 gives mean values of physiological responses of four subjects while working with six handle heights and also the details of ploughing operation in experiment 1. The heart rate varied from 103.9 to 109.1 beats/min and the oxygen consumption from 0.481 to 0.605/l/min. However, in both cases, the differences
Fig. 2. Measurement of downward force (in the direction of handle) applied by the operator on handle during operation.

Table 2. Postural discomfort experienced by the subjects and parameters of harrowing operation at different handle heights (Experiment 2).

<table>
<thead>
<tr>
<th>Handle height</th>
<th>Overall discomfort rating (ODR)</th>
<th>Body part discomfort scores</th>
<th>Force applied on handle N</th>
<th>Depth of operation mm</th>
<th>Speed of operation km/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1</td>
<td>0.85 MH</td>
<td>2.8</td>
<td>20.5</td>
<td>103</td>
<td>87</td>
</tr>
<tr>
<td>H2</td>
<td>1.00 MH</td>
<td>2.4</td>
<td>16.3</td>
<td>101</td>
<td>93</td>
</tr>
<tr>
<td>H3</td>
<td>1.15 MH</td>
<td>4.1</td>
<td>33.5</td>
<td>86</td>
<td>91</td>
</tr>
<tr>
<td>H4</td>
<td>1.30 MH</td>
<td>4.6</td>
<td>45.8</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>H5</td>
<td>1.45 MH</td>
<td>5.5</td>
<td>48.5</td>
<td>76</td>
<td>84</td>
</tr>
<tr>
<td>H6</td>
<td>1.60 MH</td>
<td>6.0</td>
<td>53.8</td>
<td>71</td>
<td>81</td>
</tr>
<tr>
<td>F_{(3,15)}</td>
<td>11.70</td>
<td>5.67</td>
<td>6.50</td>
<td>1.63</td>
<td>2.27</td>
</tr>
<tr>
<td>Significant at p &lt;</td>
<td>0.001</td>
<td>0.005</td>
<td>0.005</td>
<td>0.25</td>
<td>0.10</td>
</tr>
</tbody>
</table>

were not significant at $p < 0.05$.

Table 2 gives data on postural discomfort along with details of ploughing operation. The overall discomfort rating (ODR) was lowest for $H_2$ treatment, its value being 2.4 on the 8-point scale. The body part discomfort score was also lowest (i.e. 16.3) in $H_2$ treatment.

**DISCUSSION**

*Heart rate*

Working posture has influence on heart rate. If the hands are raised from
HANDLE HEIGHT FOR BLADE HARROW

bench level to shoulder level and above, the heart rate would be higher (ASTRAND et al., 1968). However, the circulatory stress imposed due to increase in handle height could not get reflected in the heart rate data because the magnitude of force applied by the subjects on the handle decreased with increase in handle height. The downward push force in the line of handle varied from 98 N to 50 N (in experiment 1) and 103 N to 71 N (in experiment 2), in treatment H₁ to H₆. The subjects could apply the largest force in H₁ treatment. However, the treatments H₁ and H₂ were at par (at \( p < 0.05 \)). At higher handle height, it was difficult to apply the downward force and therefore the depth of operation was less. In H₅ and H₆ treatments, maneuverability of the implement was also poor.

**Oxygen uptake**

Oxygen uptake is the measure of physical workload on the subject during the operation. Here, the physical workload was in three components, viz. walking, applying a downward push by left hand, and controlling the bullocks by holding reins and stick in right hand. The variation observed in \( \dot{V}O_2 \) uptake in different treatments was not significant at \( p < 0.05 \).

**Postural discomfort**

For minimum muscular fatigue during work, the hands should be positioned below the waist level (HERBERTS et al., 1980; WIKER et al., 1989). As mentioned earlier, harrowing operation involves downward application of force while walking behind the harrow. It was observed that at H₁ height the operator had to stoop, thus causing some discomfort in waist region. At higher handle heights, i.e. H₃, H₅ and H₆, the discomfort was experienced in arms and shoulder region. The overall discomfort rating and the body part discomfort scores (Table 2) show that H₂ was the best height as it had the least postural discomfort scores.

**Optimum handle height**

The criteria for deciding optimum handle height would be minimum postural discomfort, lower physiological cost and better harrowing operation. It can be seen that at H₂ handle height, the postural discomfort was minimum and the operation was better. The heart rate and oxygen uptake at this handle height were 103.9 beats/min and 0.536 l/min, respectively. Therefore, this handle height can be taken as the optimum one for the blade harrow (Fig. 3). The H₂ height is equal to 1.0 metacarpal III height. As per the anthropometric data available (GITE and YADAV, 1989), the 5th, 50th and 95th percentile values of metacarpal III height of the Indian agricultural workers are 637 mm, 685 mm and 732 mm, respectively. Thus the optimum handle height for a blade harrow works out to be between 637 to 732 mm. Preferably, the height should be adjustable within this range. For a fixed type handle, a height of 685 mm is recommended. It would be equal to 1.07 MH of the 5th percentile worker and 0.94 MH of the 95th percentile worker.
Fig. 3. Posture of the operator while working at optimum handle height.

Comparison with mould board plough

In the experiment on animal-drawn mould board plough (Gite, 1991), the optimum handle height was found to be equal to $1.15 \text{MH}$ and for a fixed-type handle: a height of 770 mm was recommended. The handle height for blade harrow is lower than this value. In mould board plough, the operator had to provide support for stability of plough in addition to application of downward force whereas in blade harrow operation, the operator had to apply downward force only. Therefore, in blade harrow, the subjects preferred lower handle height.

CONCLUSION

For an animal-drawn blade harrow, the handle height should be adjustable between 637 to 732 mm. For a fixed-type handle, the height should be 685 mm.

REFERENCES


BIS (1979) Indian Standard on Specification for Animal Drawn Blade Harrow, Guntaka type (First
HANDLE HEIGHT FOR BLADE HARROW

revision), IS: 2564-1979, Bureau of Indian Standard, New Delhi.


ICAR (1960) Indigenous Agricultural Implements of India—An All India Survey, Indian Council of Agricultural Research, New Delhi, p. 401.


