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REVIEW- PERFORMANCE EVALUATION OF LEVER OPERATED PORTABLE SPRAYER

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Abstract: The reviews of relevant work related to the ergonomics and design of lever operated portable sprayers carried out by various researchers are presented in this paper. The reviews of researches presented in this paper are ergonomics evaluation of lever operated portable sprayers, various components of sprayers, and various parameters for ergonomics evaluation like heart rate, oxygen consumption and postural discomfort,

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INTRODUCTION

Spraying is one of the important operations in crop production. Insects and pests are predominant factors responsible for reduction in the crop yield. The need for chemical application arises from man's desire to protect his crop from attacks of various pests and diseases. The 'increased use of fertilizers and irrigation facilities resulted in higher incidence of pest, weeds and diseases making these high yielding varieties less remunerative. This necessitated plant protection measures in large scale.

LOP sprayers are commonly used to apply pesticides other agricultural chemicals for protection of crops or plants from insects and pests. Sprayer-development followed two basic paths i.e. small operator carried units, and large machines that required a cart, wagon or motorized vehicle for transport. One of the first large scale use of LOP sprayers involved fungicide application to vineyards in France during the late 1880's. The emergence and development of blow Moulding; man-made material in recent years has made a major change in construction of LOP sprayers. Due to this technique lighter and chemically resistant plastic models became available. Some attention has also been paid to construction of unit with curved tanks or which include some of back (lumber) brace, both aimed at making LOP more comfortable to carry and operate.

Performance Evaluation of LOP Sprayers

Early work in the field of sprayer evaluation was concerned with equipment for vector control. Hall (quoted by Matthews, 1985) suggested test procedures and test rig for assessing the basic material strength and durability of compression and stir-up pump sprayers. Subsequently Matthew's (1969) developed a test rig for simulated field use of lever operated sprayers. The testing procedure of lever operated sprayers was reviewed at different centre's **(Sastry, 1971). Bindra (1971) and Ramarao (1971)** also dealt with testing standards and test procedure for plant protection equipments.

Sutherland (1979) outlined format of specification for comparative evaluation of lever operated and motorized knapsack sprayers. This format could be used either as an absolute standard or as a means of comparing machines. For the LOP sprayers, the format was in two parts, Part-I covered dimensions, construction and performance and Part-II covered structural strength and durability. A scoring system was suggested which was based on the criteria such as efficiency, liability, safety, comfortable operation, strength, repairs etc. A result of the farmer's surveys and discussions with them was the basis for giving the scores points. Based on this study Sutherland (1987) formulated a procedure for comparative evaluation of portable sprayers.

Matthews and Thornhill (1989) suggested checklist and procedure for evaluation of lever operated sprayers.

The Bureau of Indian Standards has formulated standard specifying methods for testing of manually operated sprayers **(BSI, 1982).** Regional Network for Agricultural Machinery (RNAM) has also brought out the test code and procedure for hand operated sprayers (RNAM, 1983). However all these test codes mainly deals with mechanical testing of sprayers and very little importance has been given to ergonomic aspects.

Ergonomics Evaluation of LOP Sprayers

There have been few efforts earlier related to ergonomics evaluation of sprayers. **Singh and Kaul (1972)** sported energy expenditure of manual sprayer as 0.49 l/min. The spraying operation was found equivalent at 118.14 kg m/min of mechanical work on bicycle ergo meter. Backache as well as stiffening of neck was reported by the subjects. **Nag (1980)** studied the physiological workload of spraying operation. The heart rate and oxygen consumption were found to be 125.5 beat/min and 0.653 l/min, respectively. Fisher and **Deutsch (1985)** highlighted the problems and suggested ways to evaluate the sprayer from ergonomics view point. **Ghugare (1989)** carried out the ergonomical studies on operation of LOP sprayer. The mean heart rate, oxygen uptake and energy expenditure were found to be 94.6 beat/min, 0.45 1/min and 9.48 kJ/min, respectively. The mean overall discomfort rating were 3.4,5.0 and 5.7 on an eight point discomfort scale (0 = no discomfort, 7 = extreme discomfort) and the mean body part discomfort score were 65.8, 93.8 and 89.1 at the end of 1st, 2nd and 3rd fill of sprayer, respectively. The maximum discomfort was experienced at the left clavicle region followed by lower back, neck, left thigh and right clavicle. He also studied 18 body dimensions and shape of back and data were collected for 10 subjects. Based on the data generated in this project, a draft test code and procedure for agronomical evaluation of LOP sprayers was formulated by **Gite and Pandya (1909), Phadke (1990)** carried out a study on four different types of knapsack sprayers to validate this test code. He found that effort required in downward (pressure) stroke for operation of four sprayers, were 6.10, 6.56, 5.32 and 11.15 kgf for Hi'-Tech, LOK, Hi-Flo and Knapsack sprayer respectively. Whereas the corresponding values in (idle) stroke were 1.28, 2.24, 0.45 and 3.17 kgf. The mean heart rate (beats/man) during sprayer operation were 88.4, 93.0, 91.3 and 94.2 for Hi-Tech, LOK, Hi-flow and Knapsack sprayers respectively whereas the. Corresponding increase in heart rate over walking were 10.15, 11.6, 9.8 and 14.6 beats/min. The mean oxygen uptake (1/min) during sprayer operation was 0.38, 0.37, 0.33 and 0.43 and corresponding values of increase in oxygen uptake over walking were 0.15, 0.16, 0.13 and 0.22 1/min for Hi-Tech, LOK, Hi-Flo and Knapsack sprayers, The mean overall discomfort rating (ODR) reported were 5.5, 4.9, 4.0 and 6.5 and mean body part discomfort scores (BPDS) were 109, 75, 56 and 129 for Hi-tech, LOK, Hi-Flo and Knapsack sprayers, respectively and the increase in ODR over walking and increase in BPDS over walking were 3.8, 3.1, 2.2, and 4.8 and 89,53, 34 and 107, respectively. The ergonomics scores calculated for four sprayers were 78.1, 69.5, 61.6 and 50.7 respectively for four sprayers, **Meshram (1991)** carried out the study on design improvement in LOP sprayers for better ergonomical performance. The pump design was modified by him to reduce the effort required in handle operation of sprayer from 7.75 kgf to 5.97 and 4.33 kgf in two models for the desired mechanical performance.

Tank capacities and weights of sprayer

In LOP sprayer operations worker has to carry the r in rucksack mode. The WHO (1964) specified that the capacity of the tank should be between 7.5 and 15 liters. The weight of sprayer when empty but equipped for operation should not exceed 6.8 kg. **Matthews (1979)** suggested that the capacity of the tank should be about 15 liters so that; total weight of sprayer is not too excessive to be carried by the operator. The Indian Standards IS-3906 Part-I (1982) specified tank capacities as 10, 14, 16 or 18 liters. **Thornhill (1982)** reported that operator will get tired while carrying an excessive weight particularly in hot weather. So the empty machine should be as light as possible with good capacity weight ratio i.e. liquid capacity (liters) divided by the empty weight (kg) and this should range considerably from 2 to 4 l/kg. As per BIS-3906 Part I (1982), the empty weight of sprayer should not exceed 9kg. **Garg (1990)** has suggested tank capacities as 10 liters for low volume and 12 to 16 liters for medium volume sprayers**. Phadke (1990)** suggested tank capacities between 10 or 12 liters to reduce postural discomfort of the operator.

Location and Type of Pump

The location and type of pump has a regional Preference and traditions. In South East Asia, for example over the shoulder lever type pumps are more popular than the underarm type found elsewhere. It is also a matter of individual preference and convenience. The OTS - over the shoulder - lever position allows an operator to easily switch from right to left hand pumping and to move through tall closely spaced plants more readily than an underarm lever. The long curved OTS lever arm can *be* inconvenient during filling, emptying, and transporting a LOP sprayer. Also an OTS configuration usually operates only piston pumps and may not be suitable for diaphragm pumps. A piston pump (positive displacement) usually produces more output than a diaphragm pump, but the later often requires less energy for Operation and maintenance. Diaphragm pumps generally resist wear better than piston pumps when using wet table powders **(Fisher and Deutsch, 1985)**

Pump Parameters (Pump size)

The pressure fluctuation is dependent upon the of pressure chamber. For uniform spray, pressure fluctuation should be minimum. IS-3906 (Part I) 1982 that the pressure chamber shall have a minimum capacity of eight times the piston displacement. In commercial models Of LOP sprayers the pressure chamber generally varies from 500 to1000cc. As per the Indian Standard (IS: 3906 Part 1-1982) for piston type sprayer the inner diameter of pump cylinder should not be more than 5.5cm and thickness and height of piston shall not be less than 0.25mm and 13mm respectively.

Garg(1990) recommended reduction of piston displacement and increase in pump operating speed as the pressure chamber used in LOP sprayer are of smaller capacities

Stroke length

As per the Indian Standard (IS: 3906 Part 1-1982) Stroke is the maximum travel of the piston rod in one direction when the handle moves from the maximum upward to the maximum downward position. For a complete stroke **Sutherland (1979)** specified lever movement at handle grip as 30 cm to 40 cm.

Number of strokes per minute

There is no research data available about the optimum frequency of handle operation for pump of LOP sprayer. The operating frequency depends upon the working pressure, piston displacement, volumetric efficiency and desired discharge (i.e. type of nozzle used). **Sutherland (1979)** reported the pumping rate as 12 to 26 strokes per minute in different LOP sprayers. **Garg (1990)** reported that the pump was operated at a speed range of 25 to *35* cycles' per minute in the field, and therefore, a pump speed of 30 cycle per minute should be specified for conducting various tests viz. pressure development test, discharge rate, volumetric efficiency and endurance test, on manually operated sprayers.

Range of handle Movement

There is no data available about the optimum range Handle of movements. As per IS-3906: Part-I (1982) the handle movement should be 35° upward to 35° downward (i.e. total of 70° or less) of a horizontal plane passing through centre line of the handle pivot.

Strap Attachments

Strap attachment location influences sprayer balance and comfort. Upper ends of the straps should be attached near the sprayer top. Those should be wide enough to evenly distribute the sprayers load on operator's shoulders. If possible strips should be padded at shoulder contact points. It should be possible to easily secure the straps at the skirt of the sprayer **(Fisher and Deutsch, 1985). As per IS-3906: Part-I (1982)** two straps of not less than 80 cm in length and 3.87 cm in width is to be provided and there should be provision for adjustment of length of each strap.

Maximum Force exerted by arm

In the LOP sprayer operation, the operator applies push-pull force for moving the lever in downward – upward stroke. Principle limb movement involved in the sprayer operation are flexion and extension of arm, involved joint being elbow, and suspiration and proration of palm involving wrist The push is applied in extension while the pull in flexion mode,

Morehouse (1959) gave the maximum elbow flexion a extension strength as *27* kgf and 9 kgf respectively. **Caldwell (1962)** measured the maximum force of arm extension at five elbow angles at 25° intervals between 60° and 160°. It was found that the strength of the response was influenced by the elbow angle. The subject was told to push as hard as he could on the handle and to reach maximum output in about 3 sec. It was found that there was no appreciable difference between the force measured at 110°, 135° and 160° of elbow angle. The mean strength was 17.4, at 60° elbow angle and increased to 22.4 kgf at 110° elbow angle**.** **Kroemer (1970)** suggested strength tests duration as less than 1° seconds, to avoid muscular fatigue

Murrel (1979) mentioned that the strength of flexion was almost one and half times that of the extension**. Kromer and Marras (1981)** studied the male and female subjects and found that maximum strength in elbow flexion were 34.2kgf and 14.4kgf, respectively. Legg and **Pateman (l984)** suggested that average values of maximum flexion and extension of elbow for eleven male subjects as 26.7 kgf and 17.7 kgf for right hand and 27.6 kgf and 18.0 kgf for left hand, respectively. Sato and Ghashi (1989) studied relationship between the force level of sustained isometric contraction and the time until two indices of muscular fatigue was con-pared for the right elbow flexion between 6 young women and 6 men. The strength of the maximum voluntary contraction (MVC) measured at the wrist with the elbow at right angle was significantly greater in men (26.7 ±3.5 kgf) than in women (16.3 ± 2.3 kgf**). Seki (1991)** studied isometric muscle strength of elbow flexion, elbow extension and hand grip. The speed of exertion of muscle strength was also determined by the subject, except that he had to finish) each trial within 5 to 10 seconds and he had reported that

Elbow Flexion: Maximum strength of right arm 22.l|kgf and of left arm 17, 6 kgf

Elbow extension. - Right 13.7 kgf left ana . 12.9kgf

Kumar (1991) conducted study to determine arm values for isometric and isokinetic effort around the human trunk. Subjects were instructed to build gradually to their maximal strength within the first two seconds and maintain for another three seconds for isometric trials. A rest period of at least two minutes was allowed to ensure and lack of fatigue.

Anthropometric Data for LOP Sprayer Design

There are few studies available which give about selected body dimensions of Indian agricultural workers. These studies have been summarized by **gite and Yadav (1985)** and data on 14 body dimension i.e. mean, 5 percentile values, and 95 percentile values have been given. **Ghugare (1989)** studied the shape and size of back of 10 workers and suggested improvement in the tank shape of sprayer

Parameters for Ergonomic Evaluation

1. Heart rate

Heart rate data are used to estimate the workload imposed on the subject due to various operations. Increase in heart rate is considered as a reliable index of the amount of energy expanded by an individual performing a task.

Leblanc (1957) mentioned that the work and recovery of pulse rate of human beings exercising at different levels of activity have shown to be value of judging the intensity and duration of work performed. Since the heart rate is directly affected by circulatory change, its use as an index of fatigue resulting from muscular activity was also suggested by him**. Suggs and Splinter (1958)** used this index as a basis of comparing the relative difficulty of several farm tasks. **Burger (1969)** reported that use of heart rate for workload estimation had the primary advantage of simplicity and quickness of measurement. However heart rate is influenced by many other factors than the task intensity alone. Heart rate increase considerably in general and regional dynamic activity, in static muscular load, during heat exposure and under emotional stresses from work. **Sengupta et al. (1979)** reported that there was no significant difference in heart rate at light workload (having HR below 90 beats/min) when compared at 22°C and 30°C temperature.

The resting heart rate does not normally give any information over and above that provided by the work test. At low levels of physical activity there may be some variation in resting heart rate data due to emotional stress etc. Therefore, this data is not given much importance during ergonomics trials **(Astrand and Rodahl, (1977),** When work is started from resting condition, heart rate immediately increases and approaches to equilibrium with the ask within a relatively short time. For light to moderate asks equilibrium is reached in 3 minute or even earlier. In any case after 4 to 5 minutes of work, the heart rate generally reaches the steady state. In such conditions, the minute heart rate readings will not differ by more than 5 beats/ min **(Astrand and Rodahl, 1977).**

2. **Oxygen consumption**

The heart rate serves as an index of stress on worker whereas the oxygen consumption is supposed to be the absolute measure of work load. Various aspects of oxygen consumption as a measure of work load have been dealt with by **Astrand and Rodahi (1977), Brouha (1960) and Consolazio et al (1963).**

Oxygen uptake is extensively used to determine the energy cost of different human activities. In field studies the classical method was to collect the expired air in Douglas bag, measure it and analyses the samples for oxygen concentration. With the development of portable devices for measuring of expired air volume and oxygen content, it has become easier to measure oxygen uptake in various operations. **Harrison et al. (1982)** carried out studies on Morgan oxylog and concluded that this equipment was sufficiently accurate for reliable determination of oxygen consumption under field conditions.

Measurement of oxygen consumption or heart rate may be used to evaluate heavy workloads involving a substantial proportion of the body's muscles but may not be sensitive enough to evaluate the local fatigue of small muscle groups **(Bush et al., 1988).**

3. Postural discomfort

Bad Postures and probable sites of pain or other symptoms were studied by **Van Wely (1970).** According to him, stooped position of work may cause pain in lumber region and erector spine muscles. Any such inconvenient work postures result in muscular pain. **Corlett and Bishop (1976)** suggested a technique for assessing the postural discomfort. With the help of this technique, they could successfully study the effect of improvement in posture on performance of subjects with spot welding machines**. De and Sen (1986)** used this technique for assessing postural discomfort during plugging operation for in paddy fields. **Yu and keyserling (1989)** modified this technique slightly and used it for evaluations of new work seat for industrial sewing operations. Many other research workers have also used the **Corlett and Bistop (1976).**

REFERENCES

1. [Bindra O. S., 1971] Testing of plant protection equipment; establishment of central test house – laying of standards etc. paper presented in first group discussion held at (PPTI) Hyderabad from Feb. 26-28.

2. [Bindra O. S. & singh H. 1971] Pesticides application equipment; Oxford and IBH Publication Company.

3. [BIS., 1982](Part –I) Specification for hand operated knapsack sprayer – piston type. IS – 3906 (part- I) 1982 Bureau of Indian Standard, New Delhi.

4. [BIS., 1982] Method of test for manually operated sprayers; IS- 10134-1982; Bureau of Indian Standards, New Delhi.

5. [Burger G. C. E., 1969] Heart rate and concept of circulatory load. Ergonomics 12(6): 857-864.

6. [Bush J. C. et al., 1988] Influence of dynamic factors on the lumbar spine movement in lifting Ergonomics 31(2) :211-216.

7. [Corlett & Bishop., 1976] suggested a technique for assessing the postural discomfort.

8. [De A. & Sen R. A., 1986] Ergonomic evolution of ploughing process of paddy cultivation in India, General of Human Ergology 15(3): 103-112.

9. [Fisher H. H. & Deutsch., 1985] Lever Operated Knapsack Sprayer IPPC document no 53-A-84,USA.

10. [Garg C. L., 1990] Standardization and Performance evaluation of agricultural sprayers; paper presented at Industrywise Conference on pest control equipment held at C.I.A.E., Bhopal on 22February, 1990.

11. [Ghugare B. D. et al., 1991] Adhaoo, S. H.; Gite, L. P. ; Pandya . A.C. and Patel, S. L. Ergonomic evaluation of a lever operated knapsack sprayer; Applied Ergonomics. 22 (4) : 241-250.

12. [Gite L. P. & yadav B. G., 1986] Instrumentation for measurement of human effort, energy expenditure and instrumentation for testing of agricultural machinery. Technical Bulletin NO. CIAE/IDP/86/1 C.I.A.E. Bhopal.

13. [Gite L. P. & Pandya A.C., 1989]. Test code and procedure for ergonomic evaluation of a lever operated knapsack sprayer. A draft proposal Central Institute of Agricultural Engineering. Bhopal India
14. [Gite L.P. & Pandey, M.M. 1992] A setup for simulation of force application on the handle of LOK Sprayer. Central Institute Of Agricultural Engineering Bhopal.
15. [Harrison M. H. et al., 1982] The oxylog – An evolution Ergonomics 25(9): 809-820.
16. [Kroemer K.H.E., 1970] Human strength terminology measurement and interpretation of data human factors 12(3) :643-653.
17. [Matthews G.A. & Knight A.A.., 1969]Ergonomics in agricultural equipment design, National Insitute of Agril. Engg. Silsoe U. K.
18. [Matthews G.A. & Thornhill E., 1989] Sprayer testing at Britain's JPARC, Portable spraying machinery 1988-89, Imperial College of silwood Park Ascot. U. K.
19. [Morehouse L.E., 1959] Strength of human factor 1(2): 43-48.
20. [Murrel K.H.F., 1979] Ergonomics- Man in his working environment. Chapman and Hall,London.
21. [Nag p. k. et al., 1980] Occupational workload of Indian agriculture workers; Ergonomics, 23(2) :91-102.
22. [Sastry V.C.S., 1971] Testing of plant protection equipment at testing centers. Paper presented at first group discussion at CPPTI. Hyderabad from Feb. 26-28
23. [Sengupta A.K. & Sarkar D. N., 1979] Mukhopadhyay and Goswami D. C. Relationship between pulse rate and energy expenditure during graded work at different temperatures; Ergonomics, 22(11) 1207-1215.
24. [Singh, H. & Kaul . R. N., 1972]Human energy requirements of selected farm operations. J . of Agril. Engg. 9(3) : 44- 52.
25. [Suggs C. W. & Splinter W. E., 1958]Time and energy analysis of agricultural tasks: Trans ASAE 1; 50-52.
26. [Sutherland J. A., 1979] The evaluation of knapsack sprayers and motorized knapsack sprayers; PANS, 25 (3) : 332-364.
27. [Sutherland, J. A., 1987] Procedures For the Comparative evaluation of knapsack sprayers natural resource institute, Londan, UK.
28. [Wely P.V., 1970] Design and diseases , applied Ergonomics 1(5) : 262 -269