Design Of Clove Flower Picking Ladder Ergonomic Footstep Clamp Model

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Abstract. Clove farmers who are currently still using wood as a footrest mounted on bamboo, more specifically, this invention relates to the design of a new footing design for bamboo stairs using metal clamps as a substitute for wooden steps which are often at risk of breaking. To overcome existing problems, craftsmen need to be given a bamboo ladder (Banggul) for picking clove flowers that is ergonomic and safe using strong and light metal clamps as an ergonomic footrest that can be installed and removed and the distance of the bamboo steps can be adjusted according to anthropometry. the farmer's knees are high so that when he climbs the bamboo steps his working attitude is natural. The results showed that the workload of farmers reached 127.54 ± 4.90 dpm (heavy workload), while the resting pulse 75.61 ± 0.506 dpm or experiencing an increase 51.93 ± 2.19 dpm. Musculoskeletal complaints before work 30.32 ± 1.52 and after-work complaints score 51.20 ± 5.021. Fatigue scores after work increased from before work 32.10 ± 3.354 while the fatigue score after work increased to 55.11 ± 4.321.

1 Page layout

One of the problems of the Munduk Tourism Village [1] is that the potential for coffee and clove harvests has not been developed to drive the village economy and create business opportunities. The Munduk Tourism Village, which is located in a mountainous area, has been a rainwater catchment area for Bali and a center for Arabica coffee since 1870. Recently, the coffee commodity has been displaced by clove intercrops which have become the dominant vegetation to this day. Cloves Eugenia aromatica and Syziginium aromaticum belong to the Myrtaceae family. This plant is in the form of a tree, can reach a height of 20-30 m, and can be more than 100 years old [2]. One of the tools for picking clove flowers is a ladder made from a piece of bamboo filled with wooden rungs which are installed parallel to the bamboo by making holes in the bamboo and installing wood as rungs. The steps are mounted on bamboo books with a distance between the holes of ± 50 cm. The number of stair holes made depends on the length/height of the bamboo. For the rope bamboo type, the number of holes made is 15-20 holes, while for petung bamboo the number of holes can reach 35 holes.

Based on Minister of Manpower Regulation No. 09 of 2016, concerning work at heights, it is mandatory to pay attention to occupational safety and health factors, namely

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providing work equipment to minimize the distance of falls or reduce the consequences of workers falling. Working at height is any person who works at a height of more than 1.8 meters above the ground and has the potential to fall so they must be equipped with an arrestor (body protection using a double lanyard) or must be protected with a handrail or safety net [3]. The use of bamboo as a ladder tool for picking clove flowers has the potential to cause danger or hazards in the workplace, such as falls due to negligence or broken steps made of wood and the steps becoming slippery during the rainy season. If these hazards are not controlled properly, they can cause fatigue, illness, injury and even serious accidents [4]. According to the Indonesian Ropes Access Association (2009) work at height is a form of work that has the potential danger of falling and of course other dangers [5]. According to the Rope and Work Corporation, work at height is work with a high level of risk (high risk activity) which requires special knowledge and skills to carry out the actual work. Considering that hazards exist in almost all workplaces, efforts to prevent and reduce risks that may arise as a result of the work process need to be carried out immediately. Through the risk management process, risks that may arise can be identified, assessed and controlled as early as possible through preventive, innovative and participatory approaches [4].

One solution is to increase the application of appropriate technology for clove farmers through an ergonomic approach by considering humans as the main factor driving work [6] and research results have also identified the human and social capital of traditional artisans is not sufficient to survive the rapid changes in the socio-economic sector of society [7]. Inefficient design of work tools causes exposure to physical ergonomic hazards in the workplace [8]. Working conditions like this will hasten exhaustion and result in numerous complaints, pain, and injury to workers' limbs in the short and long term. Bending actions in the workplace should be minimized, if not avoided, because they might induce musculoskeletal system disturbances [9]. These problems are most common in specific muscles, particularly active muscles. NIOSH can also employ a variety of assessments. [10] and the ultimate goal is to enhance workplace attitudes and decrease musculoskeletal problems. [11]. Musculoskeletal issues are exacerbated by workstation facilities; some manual laborers require stretching exercises to reduce musculoskeletal complaints [12], in order to boost job productivity and health [13]. Based on the results of interview observations with clove flower picking farmers, one of the problems encountered in using bamboo ladders is that the steps are made of small wood which has the potential to break when used. For this reason, research on the application of ergonomics was carried out through a participatory approach to the process of picking clove flowers through the design of ladder clamps so that interventions were adjusted to the needs of workers [14] and reduced the occurrence of complaints on body parts [15].

2 Methods

This research was carried out by observing 20 clove flower picking farmers in Munduk Village, Buleleng Regency. Stair clamps are designed using anthropometric data on the greatest height of the feet that can be naturally elevated to establish the distance between steps and data on the width of the feet to determine the width of the footrest or step area. The workload is assessed by pulse rate, tiredness, and muscular complaints. A pulse meter was used to measure the pulses of clove flower plucking farmers. To predict fatigue, a 30-item general tiredness questionnaire with four Likert scores was utilized. Skeletal muscle disorders are predicted by the Nordic Body Map questionnaire. Quantitative descriptive statistics were used to examine workload, weariness, and skeletal muscle complaints. Then, an ergonomic stair model is constructed.
3 Results And Discussion

3.1 Farmers Work Attitudes Picking Clove Flowers

The clove harvesting process is carried out by the picker standing on a bamboo ladder called Banggul made of bamboo filled with wooden sticks as footrests placed parallel. The picking process is done manually by climbing and standing on a bamboo ladder. Apart from the main workload, there is also a psychological workload because they have to stand at a height and stand on stairs while working. The results of interviews with clove-picking farmers show that the job of picking clove flowers is included in the heavy work category because they have to do their job by standing on a bamboo stick and at a height. The workload of clove flower picking farmers can be in the form of the main workload, namely picking cloves, accompanied by additional workload in the form of high psychological workload and the threat of dangers such as insects and strong winds as well as the risk of falling.

![Figure 3.1 Work Attitudes of Clove Flower Picker Farmers](image)

The farmer's working attitude (Figure 3.1) when picking clove flowers is standing with his feet on a step made of wood mounted on a bamboo stick. When clove flower picking farmers carry out their duties, it is unavoidable that there will be unnatural working attitudes such as bent legs, twisted hands and the body having to tilt to the left or right, other unnatural working attitudes. Work processes that are accompanied by additional burdens such as the use of inadequate work equipment, the psychological burden of height and standing at a height that is not ergonomic can certainly cause various complaints. The clove picking farmer averages 2 to 2.5 hours on one side of the harvest. The higher the body's activity, the greater the body's metabolism, which will result in greater O2 requirements and the heart rate will increase [16]. In the short and long term, this condition will increase weariness and bring numerous complaints, pain, and harm to the operator's limbs. [17]. Musculoskeletal problems are pains in the skeletal muscles that range from very minor to quite intense. If the muscles are subjected to static loads frequently and for an extended period of time, it might result in complaints in the form of joint, ligament, and tendon injury. These are commonly referred to as musculoskeletal disorders (MSDs) or injuries to the musculoskeletal system [18]. Musculoskeletal issues are caused by environmental variables or work conditions. Stretching exercises are required for some manual material handling employees to reduce musculoskeletal complaints [19], [20], allowing productivity and occupational health to improve [21]. With the increasing complexity of work machines and equipment used, an ergonomic approach in work planning is not fully adequate. Therefore, to guarantee the achievement of maximum efficiency from each operation, minimize the possibility of errors made by humans, reduce fatigue and try to eliminate all risks for operators, it is necessary to plan working conditions based on anatomical, physiological and psychological considerations of human capacities and limitations [22]. Human-machine interaction. in the use of work tools adapted to the elements of anatomy, psychology, environment and occupational health. There are three important pieces of information needed to be able to choose the best size that creates compatibility between worker and machine, namely the body size characteristics of the user population [23].
3.2 Workload of Clove Flower Picking Farmers

According to Adiputra, workload is classified into two types: 1) external workload (stressor) and 2) internal workload (stressor). External loads include tasks, organization, and environment; and 2) Internal burden is produced by individual worker elements that are both somatic (gender, age, body size, health condition, and nutritional status) and psychological (motivation, perception, desire, and others). Anxiety is one of the psychological workloads. Anxiety, or "anxiety" in English, is derived from the Latin words "angustus" (stiff) and "ango, anci" (to strangle). Individuals experience anxiety as a subjective feeling [24]. This is caused by threatening situations that cause individual powerlessness [25]. Based on the results of interviews with clove picking farmers, the anxiety that farmers feel when picking cloves is that they are worried about the breaking of the ladder straps, broken steps or in Bali it is called palit, the danger of insects in clove trees and the presence of wind that can shake the clove trees. The existence of this anxiety will be able to increase the workload on clove flower picking farmers.

The results of measuring the workload of clove flower picking farmers showed that the average working pulse reached 127.54 ± 4.90 dpm (including the heavy workload category) [26] with an average resting pulse of 75.61 ± 0.506 dpm. The musculoskeletal complaint score after work increased by 21.12 with the average musculoskeletal complaint score before work being 30.32 ± 1.52 and the musculoskeletal complaint score after work being 51.20 ± 5.021. Likewise, the fatigue score after work increased from before work, only 32.10 ± 3.354, while the fatigue score after work increased to 55.11 ± 4.321. Details are presented in Table 3.1.

Tabel 3.1 Resting Pulse, Working Pulse, Musculoskeletal Complaints and Fatigue

<table>
<thead>
<tr>
<th>Description</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting Pulse (/minute)</td>
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<td>66.00</td>
<td>78.00</td>
<td>75.61</td>
<td>0.506</td>
</tr>
<tr>
<td>Working Pulse rate (/min)</td>
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<td>130.33</td>
<td>127.54</td>
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</tr>
<tr>
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<td>31.00</td>
<td>30.32</td>
<td>1.522</td>
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<tr>
<td>complaint scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-work musculoskeletal complaint scores</td>
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<td>46.00</td>
<td>59.00</td>
<td>51.20</td>
<td>5.021</td>
</tr>
<tr>
<td>Fatigue before work</td>
<td>20</td>
<td>31.00</td>
<td>33.00</td>
<td>32.10</td>
<td>3.354</td>
</tr>
<tr>
<td>Fatigue after work</td>
<td>20</td>
<td>43.00</td>
<td>65.00</td>
<td>55.11</td>
<td>4.321</td>
</tr>
</tbody>
</table>

3.3 Results of the Design of Stairs Clamps

The Model of Bamboo Stairs on a Bamboo Stick a Clove Flower Picker, often called Banggul, uses bamboo steps made of wood and is made parallel by punching holes in the bamboo sticks and installing bamboo steps. Ergonomic bamboo ladder clamp model for clove flower picker according to this consists of: a. Semi-circular clamps that match the diameter of the bamboo which are equipped with foot mounts, b. Semi-circular clamps that match the diameter of the bamboo for fastening the bamboo, and c. Ergonomic seat or footrest according to the width of the foot which is characterized by the width of the foot according to the width of the foot, the area of the footrest is lined to prevent slipping and can be rotated 90% when not in use or closed. Another goal is to create a sense of security and comfort and ease of use by providing work tools in the form of a bamboo ladder or often called a Banggul which is ergonomic with bamboo steps that do not puncture holes in the bamboo so as not to reduce the strength of the bamboo and prevent the bamboo from rotting due to water entering the inside of the bamboo and the height of the distance between the steps of the bamboo
ladder can be adjusted according to the height of the farmer's knees so that when climbing using a bamboo ladder it can be easy and reduce the risk of complaints of pain in the legs and upper thighs.

![Figure 3.2. Ergonomic Bamboo Riser Clamps Clove Flower Picker](image)

These clamps are made with three types of diameter sizes according to the characteristics of the bamboo stem, namely the base of the bamboo with a diameter of up to 6 inches and the middle section with a diameter of 5 inches and the top of the bamboo with a diameter of 4 inches. Thus, these clamps are designed with diameters of 6 inches, 5 inches and 4 inches. The number of clamps can be installed according to the bamboo height requirements and installed at a distance of 40-50 cm or according to the farmer's natural leg lifting ability so that it does not cause complaints of pain in the knee joints and groin when climbing the bamboo ladder. Installation distance 40 – 50 cm or adjusted to comfortable knee height so that the working attitude becomes natural. There are 3 (three) clamp sizes (6 in, 5 in, and 4 in) used on bamboo stems. This size has been adjusted to the diameter of the bamboo at the bottom, middle and top, that is, the bamboo stem at the bottom will be larger in diameter and smaller at the end of the bamboo. For installation, the clamps are adjusted to the diameter of the bamboo. This clamp can be installed on a piece of bamboo without needing to make holes in the bamboo and can be installed up to a length of 15-18 meters. There are three types of clamp diameters, namely clamps with a diameter of 6 inches at the bottom/base of the bamboo, clamps with a diameter of 5 inches installed in the middle and clamps with a diameter of 4 inches installed at the top of the bamboo. This clamp is equipped with two ergonomic footrests according to the width of adult feet so that farmers can stand safely and comfortably and this clamp can be folded upwards when not in use and to make mobilization easier. Install the clamp by removing the two fastening bolts on the left and right sides. The clamps are installed simultaneously on the bamboo and the bolts are tightened sufficiently so that the clamps can be installed perfectly without tilting and do not move when used as a footrest (Figure 3.3).
4 Conclusion

Based on the discussion, it can be concluded that the work of clove flower picking farmers is included in the heavy workload category which is caused by unnatural working attitudes and additional workload due to working at heights, psychological workload, namely anxiety about heights, the risk of falling, and the risk of insect bites. The results of data collection on fatigue and subjective exhaustion also increased. The resulting clamp design is made in a semi-circular shape with an ergonomic and easy-to-market footrest and a footrest that can be folded 90 degrees upwards. These clamps are installed on a piece of bamboo according to the diameter of the bamboo.

5 Acknowledgement

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6 References


