



An Ergonomic Analysis of Indonesian Farmers in Using Agricultural Hand Tools in Relation to Their Comfort and Satisfaction

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Abstract – An intensive survey of 810 Javanese and 696 Madurese male and female farmers in the five districts of Probolinggo, Situbondo, Jember, Banyuwangi, and Lumajang revealed that the farmers in East Java, Indonesia commonly use agricultural hand tools when farming. The popular agricultural hand tools are sickle (100.0%), hoe (92.0%), big/long knife (69.3%), shovel (23.5%), sprayer (19.1%), and harrow (16.5%). During farming, farmers suffer injury at their body; where they suffer most frequent injuries on hands (75.10%). Based on Abbreviated Injury Scale (AIS), most of the farmers face injuries at minor to moderate levels. The significant correlation of hand injury with minor and moderate injury was 0.60 and 0.40, respectively. Hard material on the handle of the tool contributed as the highest influencing factor to farmers injury (44.68%). The feel of comfort and level of satisfaction to farmers in using agricultural hand tools greatly varied among different levels, which were used during farming activities. Correlation matrix was constructed between injury and comfort levels of the farmers. A significant negative correlation (-0.274) occurred between minor injury and comfort with hoe. Those who were comfortable to use hoe, were also comfortable with other hand tools (sickle, harrow, shovel, big/long knife, and sprayer) ($p < 0.05$). From the correlation matrix between injury and satisfaction of the farmers, it is evident that those who were not satisfied with hoe, harrow, shovel, and big/long knife-are victim of minor or moderate injury ($p < 0.05$).

Keywords – Comfort, Satisfaction, Agricultural Hand Tools, Indonesia Farmer.

I. INTRODUCTION

Indonesia is an agricultural country that has proven potential and abundant natural resources needed for agricultural production. Based on statistical data in 2012, Indonesia's agriculture provides employment for 36.5% of the population (41.20 million people) [1]. East Java hosted around 8.3 million farmers in 2009 [2]. In 2010, Javanese and Madurese are among the main tribes in Indonesia having population of around 100 million and 20 million, respectively. Javanese and Madurese population in East Java is about 30 million and 11.2 million, respectively [1].

Farms in East Java are still not sufficiently mechanized. They use agricultural hand tools, animal, and indigenous modified agricultural machinery when farming. Agricultural hand tools that used by farmers in East Java are believed to be not ergonomically designed. Farmers

fabricate the handle on their hand tools based on trial and error method. Because these hand tools are not based on the ergonomic design, they are likely to uncomf, dissatisfaction, or even lead to injuries to farmers. Consideration of comfort in agricultural sector especially for small/poor farmers, is not usually given its due importance while designing hand are not usually precedence as an important factor.

In the earlier 70s, [3] studied relation between inadequate work postures and pain in human body during work in industry. [4] stated that the incident of farmers' injuries are often higher than injuries in industry. Severity of agricultural injuries worsen because of low infrastructure availability, no age and gender specific work allocation, long continuous working spells and unskillful use of machines [5], [6]. [7] stated that worker-tools mismatches caused serious injuries of workers in United States. [8] reported the occurrence of agricultural injuries among farmers and revealed that the most frequently injured body parts in incidents were limbs. [9] felt lack of study on injuries in agricultural sector of developing countries because of non-availability of nationwide compiled information on agricultural injuries. [10] estimated that injury in Indian agricultural sector was 58% that caused by hand tools.

Some researchers had studied levels of comfort and satisfaction during the use of tools or equipments. [11]-[13] identified the factors affecting comfort and discomfort in using hand tools. [14] identified the factors causing comfort and discomfort in sitting. [15] designed comfortable chair for university student. [16] concluded that the majority of women farmers in Sudan were apparently satisfied with the agricultural tools they use despite their drudgery of work and short durability. [17] suggested a technique for assessing postural discomfort.

Considering the importance of ergonomic analysis for agricultural hand tools, and general lack of primary databases in content of Indonesian farmers, this research was deemed appropriately timed.

The purpose of this study is to provide data regarding to the injury to farmers based on Abbreviated Injury Scale (AIS), the level of satisfaction, and comfort level for farmers in East Java, Indonesia when using agricultural hand tools. Results of this study are expected to provide necessary input to industry that produces agricultural tools for design of such tools ergonomically.

II. METHODOLOGY

A. Measuring Key Design Dimension of Agricultural Hand Tool

Information on key design dimensions were collected from on-field measurements of popularly used agricultural hand tools that are prevailing in the study area. Measurement of the selected agricultural hand tools involved length, diameter, and weight. The measurements were made using pre-calibrated slide caliper, ruler, and digital weighing scale.

B. Survey of Farmers' Injuries, Discomfort, and Satisfaction Level

The study identified popularly used agricultural hand tools in the five districts namely Probolinggo, Situbondo, Jember, Banyuwangi and Lumajang, of East Java, Indonesia and conducted survey of farmers for obtaining information of the tools and its parts causing injury, and determining the level of discomfort and satisfaction to the farmer. A total of 1506 farmers interviewed, comprising 396 and 414 Javanese male and female farmers, and 354 and 342 Madurese male and female farmers, respectively. This study used qualitative and quantitative approaches using the primary survey method. The data collected are primary and secondary data. Primary data was collected by using scientific instruments, questionnaire, observation and in-depth interview to the parties who are competent to respond on comfort and injuries of the farmers in the province of East Java, Indonesia. While, the secondary data obtained by reviewing information about injuries, satisfaction, and comfort levels of farmers of other countries. A standard questionnaires about comfort level in body part was used (Corlet and Bishop, 1976). The injuries suffered by the farmers was categorized according to the Abbreviated Injury Scale (AIS) (Corlet and Bishop, 1976). The 6 ordinal point AIS severity scale defines injury as 0 - none, 1 - minor, 2 - moderate, 3 - serious, 4 - severe, 5 - critical, and 6 - maximum (currently untreatable). Data were statistically analyzed.

III. RESULTS AND DISCUSSION

Table 1 depicts types of popular agricultural hand tools that used by farmers in the study area. In the order of popularity, the most frequent to the least frequently used hand tool while farming are sickle (100.0%), hoe (92.0%), big/long knife (69.3%), shovel (23.5%), sprayer (19.1%), and harrow (16.5%), respectively. The values of key design features including length, diameter, and weight of agricultural hand tools were measured in the study area, and are summarized in Table 1.

Injuries at limbs and the categories suffered by the farmers according to the Abbreviated Injury Scale (AIS) are listed in Figures 1 and 2, respectively. In Figure 1, the injuries at the limbs at farmers were 81.3%. Limbs injuries of farmers consist of injury to hand, arms, legs, thighs, and feet. Most frequent injuries occurred at the hands (75.1%). Farmers experience injuries at more than once of their body part/limbs.

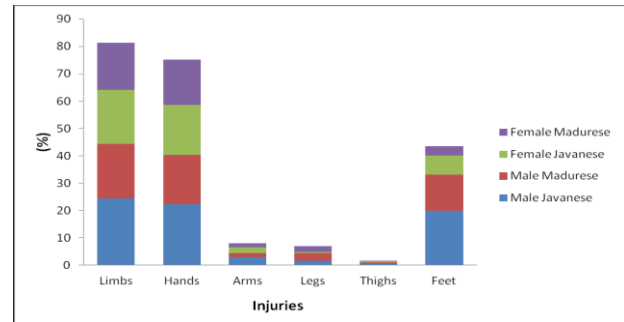


Fig. 1. Limbs injuries when using agricultural hand tool

Figure 2 shows injuries categories male and female farmers consecutively as follow: no injury (5.4 and 8.4%), minor injury (40.6 and 31.7%), moderate injury (30.9 and 21.3%), serious injury (2.8 and 2.0%), and severe injury (0.2 and 0.2%). None of the farmers experience critical or maximum injury. Some farmers experience more than once injury during farming by using agricultural hand tools.

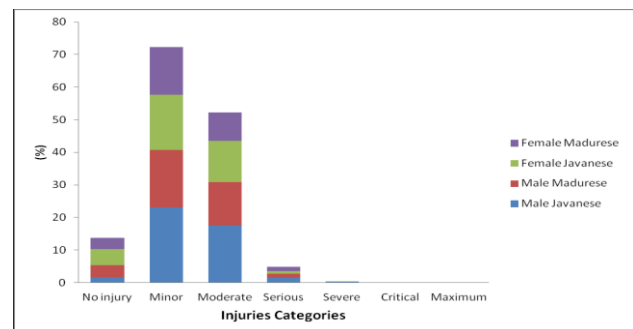


Fig. 2. Categories of farmers suffered injury

The correlation between body injuries and categories are presented in Table 2. There is a highest significant correlation between hand injury and minor injury (0.601).

The cause of lesion is presented in Figure 3. The lesion to male and female farmers are because of hardness of tools handle material (25.1 and 19.6%), followed by carelessness/recklessness (21.8 and 15.1%), then when they were the exhaustion (5.7 and 4.7%), and finally because of the handle is slippery and does not fit when on the handheld (4.3 and 3.8%).

The comfort level of farmers are varies. Majority of farmers feel comfortable (67.7%) when using a sickle, then followed by feel very comfortable (6.77%), ordinary (6.78 %) and very uncomfortable (0.8%). The comfort level of farmers when using hoe also different. Most of farmers feel uncomfortable when using hoe (52.80%), then followed by feel comfortable (35.51%), ordinary (7.14%), and very comfortable (1.3%). None of farmers feel at very uncomfortable. For using a harrow, comfort level of farmers also varies. Most of farmers feel uncomfortable when operating harrow (43.4%), then followed by ordinary (37.34%), comfortable (14.45%), very uncomfortable (4.80%). None of farmers feel at very uncomfortable. Majority farmers feel uncomfortable when operating shovel (51.7%), then followed by ordinary (33.90%), very uncomfortable (13.56%) and comfortable



7.63%. The big/long knife satisfies level written as follow. The proportion of farmers feeling comfortable and uncomfortable when they were using big/long knife are 31.0 and 31.3%, respectively, then followed by ordinary (15.81%) and very uncomfortable (2.01%). The comfort level of farmers when using sprayer on three areas comfort level that are comfortable (46.87%), ordinary (32.29%),

and uncomfortable (20.83%). Only male farmers used sprayer.

Table 3 provides correlation between injuries categories and comfort level of using agricultural hand tools. The significant correlation value ($p < 0.01$) is between minor injuries and hoe comfort level (-0.274). It means that farmers who feel comfort when using hoe will less have minor injuries.

Table 1: Key design features of popularly agricultural hand tools in East Java

Agricultural hand tool	Handle		Weight (kg)
	Length (cm)	Diameter (cm)	
Sickle	11.8-16.5	2.3-4.2	0.2-0.9
Hoe	57.2-69.4	3.8-5.3	2.3-3.4
Harrow	62.1-74.0	3.2-4.7	1.8-3.2
Shovel	42.9-58.2	5.3-6.9	2.6-3.1
Big/long knife	10.8-17.2	3.2-5.8	0.7-2.0
Sprayer	-	-	9.8-15.7

Table 2: Correlation between body injuries and injuries categories

	hand injury	arm injury	leg injury	thighs injury	foot injury	minor injury	moderate injury	serious injury	severe injury
hand injury	1	0.135**	0.121**	0.073	0.339**	0.601**	0.399**	0.064	0.036
arm injury	0.135**	1	0.122**	-0.037	0.023	0.034	0.075	0.037	-0.019
leg injury	0.121**	0.122**	1	0.028	0.232**	0.117**	0.231**	0.085	-0.017
thighs injury	0.073	-0.037	0.028	1	0.081	0.008	0.058	0.046	-0.008
foot injury	0.339**	0.023	0.232**	0.081	1	0.419**	0.359**	0.123**	0.008
minor injury	0.601**	0.034	0.117**	0.008	0.419**	1	0.299**	0.034	0.039
moderate injury	0.399**	0.075	0.231**	0.058	0.359**	0.299**	1	0.046	0.061
serious injury	0.064	0.037	0.085	0.046	0.123**	0.034	0.046	1	-0.014
severe injury	0.036	-0.019	-0.017	-0.008	0.008	0.039	0.061	-0.014	1

** . Correlation is significant at the 0.01 level (2-tailed).

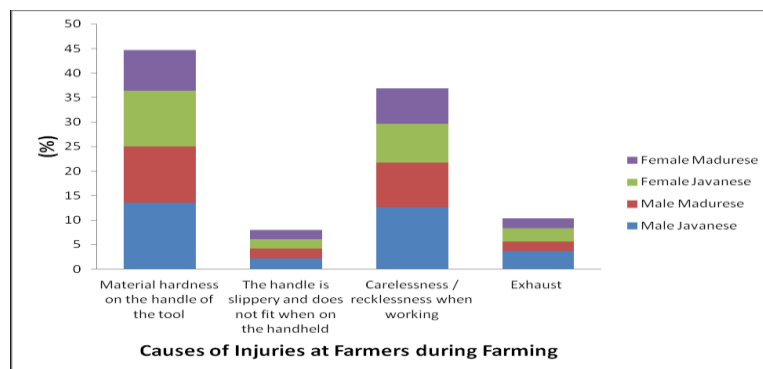


Fig. 3. Cause of injuries when using agricultural tools

The satisfaction level of farmers when using agricultural hand tools are discibed as follows. Most of farmers feel satisfy when operating sickle (55.37%), then followed by feel ordinary (22.31%), unsatisfied (19.33%), and very satisfied (2.20%). During operated hoe, farmers majority feel unsatisfied when using hoe (42.00%), then followed by satisfied (32.68%) ordinary (21.87%), very unsatisfied (5.63%), only 0.22% feel very satisfied. The satisfaction level of farmers when operating harrow are varies. Mostly farmers feel unsatisfied when using harrow (39.8%), then followed by feel unsatisfied (39.75%), ordinary (15.65%), and very unsatisfied (2.41%). Shovel satisfaction level are described as follows. Most of farmers feel unsatisfied (43.2%) then followed by feel satisfied (27.96%), ordinary (27.11%), and very unsatisfied (1.69%). For big/long knife satisfaction level, Most of farmers feel satisfied when

using big/long knife (33.91%), then followed by feel ordinary (33.62%), unsatisfied (31.03%), very unsatisfied (0.86%), and very satisfied (0.57%) respectively . Satisfaction level when using sprayer are described as follows. Most of farmers feel satisfied (46.87%), then followed by feel ordinary (40.62%), and unsatisfied (12.51%) during farming.

Table 4 shows correlation between injuries categories and satisfaction level of agricultural hand tools. The highest value for significant correlation ($p < 0.01$) is between minor injuries and hoe satisfy level (-0.163). It means that farmers who feel satisfied when using hoe will less have minor injuries.

A. Ergonomic Evaluation of Hand Tools

From anthropometric data that result from farmer body measurement can be applied to design of agricultural hand



tools. The application of anthropometric data base for design of agricultural hand tools follow on the real value of anthropometric data. For the research to design the agricultural hand tools such as sickle, hoe, harrow, shovel, big/long knife, and sprayer handle relating to design of handles of hand tools for size of handles for agricultural hand tools.

a. Size of Handle for Hand Tools

These agricultural hand tools obtain a handle and functional part. Handle design, material, and mode of farmer operation is shaped depend on factory. Farmers grasp the handle of sickle or big/long knife to cutting. Farmer holding handle of these hand tools around grip with finger and thumb are flexible. The length and diameter of handle of sickles that used in Probolinggo, Situbondo, Jember, Banyuwangi, and Lumajang is shown in Table 1.

[10] divided handle hand tools as the small handle tools (handle length <25cm), medium hand tools (handle length 25-50 cm), and long handle tools (>50 cm). The handle of sickle is small handle tools, hoe and harrow are long handle tools, shovel is classified between medium and long handle tools, and big/long knife is small handle tools.

[18] stated that a good design for handle should accordance with anthropometric dimension of user namely the length of handle should accommodate the maximum dimension of hand breadth of thumb. [19] described that the 95th percentile value of breadth at thumb is 10.9, 11.4, 10.4, and 10.4 cm for Javanese, Madurese male and female farmers, respectively. Taking a clearance 0.5 cm on each side of the grip, the length of handle comes to 11. 9, 12.4, 11.4, and 11.4 cm, respectively. The value that recommended for the length of the handle of sickle and big/long knife is 12.4 cm. For the better grip the handle diameter should not exceed the inside grip diameter of the operator. Therefore, the handle diameter should be according to 5th percentile value of the inside grip diameter of the farmer to accommodate the larger population group. These values are 3.4, 3.4, 3.5, and 3.0 for Javanese, Madurese male and female farmers, respectively.

[20] recommended for whole hand with cylindrical shape be better if have at least 10 long and thickness around 30-40 cm. [21] prescribed maximum diameter of handle was 4 cm. [22] stated that the diameter of the handle should be a little lesser than the inside grip diameter. [19] studied that the values of 1st percentile value of the inside grip diameter of farmer are 3.1, 3.0, 3.3, and 3.0 cm, respectively for Javanese, Madurese male and female farmers, respectively. Thus the diameter of the handle recommended is 3.0 cm. Based on the anthropometric considerations the modified dimensions of the sickle and big/long knife handle, hoe, harrow, and shovel is recommended 3.0 cm.

b. Weight of Sprayer

Knapsack sprayer or sprayer is manually operated and widely used by Indonesian farmers when applying fertilizers, pesticides, and herbicides in agricultural crops. In the study, sprayers that were used farmers for farming have different capacity and weight. The capacity varied from 16.0 to 25.0 liter with weight from 10.8 to 15.7 kg, respectively. When using sprayer, farmers feel satisfied, ordinary, and unsatisfied was 46.87, 40.62, and 12.51%, respectively. Because of exhaustion farmer was injuries (Fig. 3). To reduce the number of lesion because of exhaustion, farmers use the knapsack sprayer lighter than previous weight.

IV. CONCLUSIONS

The agricultural hand tools dimensions that have no design ergonomically may have contributed injuries to farmers. The shape, size and weight of agricultural hand tool have different effect to farmer’s injuries, comfort level, and satisfaction level. Most of farmers got injury because of hardness material on the handle of the agricultural hand tool. The dimension that recommended for the length of the sickle and big/long handle is 12.4 cm. Thus the diameter dimension of the sickle and big/long knife handle recommended is 3.0 cm. Based on the anthropometric considerations the diameter dimension of hoe, harrow, and shovel is recommended 3.0 cm.

Table 3: Correlation between injuries categories and comfort level of agricultural hand tools

	minor injury	moderate injury	serious injury	severe injury	sickle comfort level	hoe comfort level	harrow comfort level	shovel comfort level	big/long knife comfort level	sprayer comfort level
minor injury	1	0.299**	0.034	0.039	0.012	-0.274**	-0.007	0.042	-0.058	-0.197
moderate injury	0.299**	1	0.046	0.061	0.028	-0.070	-0.177	0.150	-0.084	0.155
serious injury	0.034	0.046	1	-0.014	0.001	0.031	-0.040	0.024	-0.094	-0.018
severe injury	0.039	0.061	-0.014	1	0.027	0.081	-	-0.054	0.068	-
sickle comfort	0.012	0.028	0.001	0.027	1	0.324**	0.153	0.229*	0.253**	0.220*
hoe comfort level	-0.274**	-0.070	0.031	0.081	0.324**	1	0.349**	0.351**	0.134*	0.208*
harrow comfort level	-0.007	-0.177	-0.040	-	0.153	0.349**	1	0.267	0.210	-0.214
shovel comfort level	0.042	0.150	0.024	-0.054	0.229*	0.351**	0.267	1	0.137	0.033
big/long knife comfort level	-0.058	-0.084	-0.094	0.068	0.253**	0.134*	0.210	0.137	1	0.226
sprayer comfort level	-0.197	0.155	-0.018	-	0.220*	0.208*	-0.214	0.033	0.226	1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Table 4: Correlation between injuries categories and satisfaction level of agricultural hand tools

	minor injury	moderate injury	serious injury	severe injury	sickle satisfaction level	hoe satisfaction level	harrow satisfaction level	shovel satisfaction level	big/long knife satisfaction level	sprayer satisfaction level
minor injury	1	0.299**	0.034	0.039	-0.005	-0.163**	-0.268*	-0.105	-0.140*	-0.040
moderate injury	0.299**	1	0.046	0.061	0.043	-0.137**	-0.124	-0.184*	-0.122*	0.054
serious injury	0.034	0.046	1	-0.014	0.041	-0.009	-0.042	0.005	-0.058	-0.049
severe injury	0.039	0.061	-0.014	1	-0.029	0.082	-	0.020	0.062	-
sickle satisfaction level	-0.005	0.043	0.041	-0.029	1	0.269**	0.208	0.163	0.221**	0.236*
hoe satisfaction level	-0.163**	-0.137**	-0.009	0.082	0.269**	1	0.322**	0.169	0.139*	0.120
harrow satisfaction level	-0.268*	-0.124	-0.042	-	0.208	0.322**	1	0.579**	0.163	0.068
shovel satisfaction level	-0.105	-0.184*	0.005	0.020	0.163	0.169	0.579**	1	0.253*	0.140
Big/long knife satisfaction level	-0.140*	-0.122*	-0.058	0.062	0.221**	0.139*	0.163	0.253*	1	0.040
sprayer satisfaction level	-0.040	0.054	-0.049	-	0.236*	0.120	0.068	0.140	0.040	1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

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