Original Article

Job Hazard Analyses (JHA) for Ergonomics Risk Factors in Malaysian Pineapple Plantation

Nur Fazrina Mohamad Salleh[a] and Ezrin Hani Sukadarin[a]

[a] *Occupational Safety and Health Program, Faculty of Engineering Technology, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia*

Corresponding Author: ezrin@ump.edu.my

ABSTRACT : *The prevalence of Musculoskeletal Symptoms (MSS) rapidly increases and it is recognized as a significant health outcome in agricultural sector. Agricultural ergonomics risk factor is one of hazards constantly arising from all job task activities including awkward postures and heavy lifting. Job hazard analyses (JHA) were conducted to assess the exposure of ergonomics risk factors in Malaysia Pineapple Plantation. The analyses performed involved two steps. They were: 1) guidelines and manual book Malaysia Pineapple Plantation as references; and 2) conducting walkthrough observation based on checklist approaches at the plantation. The identified risk factors were prolonged exposure of standing, squatting, stooping and kneeling, highly repetitive motion on the lower limbs, deviation and twisting of wrist and lastly, heavy lifting. The analyses confirmed that the exposure to ergonomics risk factors in pineapple plantation is high. It would be desirable to reduce the risk factors by educating and training the pineapple workers to perform their task with strong consideration of occupational safety and health.*

Keywords – *Ergonomics Risk Factors, Job Hazard Analysis (JHA), Malaysia Pineapple Plantation, Musculoskeletal Symptoms (MSS),.*

1.0 INTRODUCTION

Agricultural sector is one of the main sources of income in Malaysia especially for the community in rural areas. It is known that agricultural works were associated with several occupational disorders among the farmers (Das & Gangopadhyay, 2011). Several epidemiological studies showed consistent occurrence of a great number of accidents and work related diseases among agricultural workers (Kirkhorn & Schenker, 2002; Earle-Richardson et al. 2003).

The most prominent risk factors were the ergonomics factors including combination of load and working postures (Heather & John, 2003), postural activities (Reid et al. 2010), awkward working postures (Scuffham et al. 2010) and heavy lifting (Andersen et al. 2007). The pineapple industry in Malaysia is escalating as Malaysia is one of the main pineapple producers in the world because of the well-known producing quality, golden-yellow fruit (Tamrin and Aumran, 2014).

Starting and growing pineapple plants is one of the most aggressive agricultural activities (Abrahão et al. 2013). During agricultural-based pineapple plantation activities, most farmers are exposed to several types of ergonomics risk factors such as prolonged and awkward postures (Tamrin & Aumran, 2014). Moreover, the workers also exposed to heavy lifting of materials (Abrahão et al. 2013). As pineapple tree is a short rotation crop that grows with the maximum height of 1.5 meter from the ground, workers were therefore required to bend their body in positions which were defined as awkward posture for many job tasks such as cultivating, weeding, harvesting and preparation which could lead to muscle pain the feeling discomfort (Tamrin et al. 2014).

According to the most current occupational musculoskeletal disorders statistics by the Social Security Organization (SOCSO) annual report in 2016, the total numbers of affected workers were steadily increasing from

the year 2011 to 2016. There was an effort to characterize exposure to ergonomics risk factors in 2016 (Rani, et al. 2016). The distribution of one-year Musculoskeletal Symptoms (MSS) prevalence among the pineapple plantation workers showed that lower back, feet/ankles and knees were the most affected body parts. On the other hands, Guo et al. (1996) also reported that pineapple workers were exposed to direct sunlight leading to dermatitis and heavy manual work. Despite the big number of publications examining the risk of work-related musculoskeletal disorders in the agricultural field, research addressing occupational safety and health in pineapple sector is still limited, thus making it harder to provide information about ergonomics risks in the pineapple industry.

Occupational Safety and Health Administration of United States defines Job Hazard Analysis (JHA) as a technique that focuses on job tasks as a way to identify hazards before they occur (OSHA, 2002). In Malaysia, according to Department of Occupational Safety and Health (DOSH, 2008), to perform JHA, the tasks needed to be breakdown into specific steps. After that, each step for specific hazards needed to be analyzed. Next, safe work procedures to eliminate or reduce those hazards were developed and safe work procedures integrated into safety and health programs. It was a practical method of identifying, evaluating and controlling risks in industrial procedures (Chao & Henshaw, 2002).

This study aimed to document JHA which were conducted to identify the ergonomics risk factors of MSS in the process cycle of pineapple plantation and to suggest recommendations in reducing the risk factors identified. Malaysia pineapple agricultural activity involved four separated job sequences started with (1) land cultivation preparation, (2) planting, (3) maintaining crops and (4) harvesting. Each job process had its own subtask to be completed in order to ensure pineapple trees were planted with quality. JHA approaches required the subtasks to be critically analysed for hazard. JHA was conducted and documented for all four main processes to be completed with their subtasks.

2.0 METHOD

2.1 Job Hazard Analysis (JHA)

JHA method had proven to be effective in planning the safest way to perform a task. The process of JHA included three main stages (Chao et al. 2002) which were:

(i) The Identification

This stage involved choosing a specific job or activity and breaking it down into sequence of stages and identify all possible loss of control incident that might occurred during work task.

(ii) The Assessment

This stage involved evaluating the relative level of risk for all of the identified incidents.

(iii) The Action

The last stage was the action on controlling the risk by taking sufficient measures to reduce or eliminating it.

2.2 Analysis and recommendations

JHA were performed according to the guidelines by Occupational Safety and Health Administration (OSHA, 2002). It was conducted in a group of researchers by involving two steps. Step one was to refer to the manual guidebook of pineapple plantation which was published by the Malaysian Pineapple Industry Board (MPIB). This handbook contained all information and techniques from MPIB starting with the selection of soil and plant areas until the last stage which was collecting fruits. The actual purpose on establishing the manual guide book was to assist local pineapple farmers in order for them to perform the standard sequence pattern of work task. The handbook was used as a reference in JHA method for researchers to have deep understanding on the plantation processes. Step two included assessing workers exposure to Work-Related Musculoskeletal Disorders (WRMSDs) risk factors using walkthrough observation and checklist approaches at the plantation. This step was crucial in order to determine the actual activity or process during working cycle of pineapple plantation workers. Dynamic activities of workers were also recorded using video recording technique for detailed analyses on Personal Computer (PC). Four main processes with its subtasks were videotaped by using a video camera. Detailed posture analyses were undertaken for all main processes.

3.0 RESULTS & DISCUSSION

From the four cycles of pineapple plantation procession, it was shown from the analysis that ergonomics risk exposure was high among workers. The results from JHA analysis were shown in each process which was categorized in different tables. Each table discussed possible consequences of exposure and recommendations to control the exposure.

3.1 First process - Preparing cultivation land

Figure 1: The Area for Pineapple Cultivation

Fig. 1 shows the image of pineapple cultivation land. The first process in pineapple plantation work cycles was preparing the cultivation land. The area was selected according to the soil ability to support the growth of pineapple plants for plants' fertility. The area needed to be clear from all trees and well-drained. Cutting big trees was done by using machineries however, small trees and bushes needed to be managed manually by using grass sickle or chemical weed killers. Next, treating soil process was made using small hoe.

From JHA analysis, (Table 1) it shows that ergonomics risk factors involved were the forceful exertion of hand (gripping an unsupported object more than three hours per day) and prolonged stooping (more than four hours per day). The possible consequences from these two risk factors were shoulder and low back disorders. An investigation of ergonomics study conducted by (Fathallah, 2010) showed that forceful and repetitive of hand and stooping can cause hand/wrist pain and lower back disorder, while based on (Reid, McCauley Bush, Karwowski & Durrani, 2010) study, stooping posture affected most of lower extremity body parts.

Table 1: JHA for Land Cultivation Preparation

Main Process	Sub process	Ergonomics risk factors	Criterion	Possible consequences	References	Recommended controls
Preparing cultivation land	Cutting and cleaning bushes in cultivation areas	Forceful exertion of hand	Gripping an unsupported object weighing 4.5 kg or more per hand, or gripping with a force of 4.5 kg or more per hand more than 3 hours total per day	Shoulder disorders	Davis (2007); Osborne et al. (2010); (Fathallah, 2010)	Redesign tools or equipment to enable neutral postures
	Treating soil	Prolonged stooping	Constant bending of trunk more than 60° along working hours (more than 4 hour per day)	Low back disorders	Reid et al. (2010); Osborne et al. (2010); Steven et al. (2013)	Reduce exposure by changing job scheduling for more breaks to allow rest and recovery

3.2 Second process - Planting

Figure 2: Workers were Planting Pineapple Suckers on Crop Beds

Fig. 2 shows workers were doing pineapple planting. The insect and algae treatment on the pineapple suckers was done earlier by dipping them into pesticide and algae poison solution. Workers were then required to create cultivation holes on plant beds. A sharp-end wood was normally used to make the hole according to the right size. The depth of the hole should be between 10cm to 15cm or appropriately fit with the size of pineapple suckers. Next, the pineapple suckers were planted by using hands. JHA analysis showed that the ergonomics risk was the repetitive motion of hand and prolonged poor postures from planting the pineapple suckers which were stooping, kneeling and squatting. During squatting, high pressure was imposed on the knee joint of workers (Cooper et al. 1994). Meanwhile, in the study of Thambyah et al. (2005) it is shown that osteoarthritis and cartilage damage occurred in the knees as a result of frequent or high contact stress of knee surface area.

Stooping postures required a forward torso bend while keeping the legs and knees as close to neutral as possible. In an agricultural postural research by Meyer and Radwin (2007), the results portrayed that stooping postures entailing a high level of discomfort and fatigue on the body, while a squatting posture studied by Chung et al. (2003, 2005), severe knee flexion was considered as a higher level of discomfort compared to other postures, similar with Jin et al. (2009) which also concluded that in agricultural industry, when compared to kneeling and stooping, squatting was found to be the most causing lower extremity muscle fatigue and discomfort. Several studies showed repetitive task can cause muscle fatigue (Walker-Bone & Palmer, 2002; Rosecrance et al. 2006; Davis, 2007). On top of that, a study by Zadry et al. (2011) also proved that repetition task can also caused both muscles and mental fatigue. The JHA summary for planting activity can be seen in Table 2.

Table 2: JHA for Pineapple Suckers Planting

Main Process	Sub process	Ergonomics risk factors	Criterion	Possible consequences	References	Recommended controls
Planting	Seed is being dip into concentrated insect or algae poison.	Prolonged stooping	Constant bending of trunk more than 60° along working hours (more than 4 hour per day)	Low back disorders	Reid et al. (2010); Genaidy et al. (1994) Meyer and Radwin (2007)	Increase the number of workers to reduce individual workloads
	Create cultivation holes	High repetition motion	Repetitively hand motion in making hole using sharp-end wood more than 20 times per minute	Shoulder disorders Hand/wrists pain	Walker-Bone & Palmer (2002); Rosecrance et al. (2006); Davis (2007);	Establish system so workers are rotated away from tasks to minimize the duration of continual repetitive motions and awkward postures.

	Planting pineapple suckers	Awkward kneeling/squat ting	Kneeling and squatting more than three hours total per day	Hip and knee arthritis, Knee pain (including osteoarthritis)	Thambyah (2005); Maity et al.(2016); Reid et al. (2010); Chung et al. (2003,2005)	Rotate workers among different task to rest the various muscle groups of body, reduce repetition and ease mental demands

3.3 Third process - Maintaining crops

Figure 3: A worker is Doing Hormone, Fertilizing and Weed Controlling

Table 3: JHA for Maintaining Crops Process

Main Process	Sub process	Ergonomics risk factors	Criterion	Possible consequences	References	Recommended controls
Maintaining crops	Fertiliser and hormone	Prolonged standing and bending	Prolonged standing and bending alternately of trunk more than 60° along working hours (more than 4 hours per day)	Cramp legs Ankle/foot pain Low back pain	Balasu-bramanian et al. (2009) Ngomo et al. (2008)	Increase the number of workers to reduce individual workloads
		Deviation and twisting of wrist from neutral position repetitively	Repetitive motion of hand (more than 20 times per minutes)	Hand/wrist tendonitis such as carpal tunnel syndrome	Guo, (2002); Juul et al, (2005); (McKeown, 2008).	Change job scheduling for more breaks to allow rest and recovery
	Manual weed control	Highly repetitive motion in lower extremities	Repeating the same motion with the feet with little or no variation every few seconds more than 4 hours total per day	Cramp legs Ankle/foot pain	Walker-Bone & Palmer (2002); Osborne et al. (2010) (Reid et al. 2010)	Use more hard pad footwear to reduce direct contact with unstable terrain

Fig. 3 illustrates a worker who was doing maintaining crop task. This stage involved some phases namely fertilizing, hormone and weed controlling. The job task was manually done by the pineapple workers. The formulation and amount of fertilisers had been determined and there were two types of methods which were by spraying or spreading using hands. For fertilising and hormone, JHA showed that workers experienced prolonged standing and bending trunk with more than 60° throughout the working hours about more than four hours per day. They also repetitively were using their hands at least 20 times per minute. JHA analysis for manual weed control task revealed that workers repeated the same feet motion with little or no variation every few seconds more than four hours total per day. Prolonged standing can cause leg discomfort (Balasubramanian et al. 2009; Ngomoet al. 2008). A study by Messing et al. (2006) also observed that periods of prolonged standing with little movement to no movement can cause lower level of discomfort to the lower limbs. Repetitive, deviation and twisting of wrist can lead to repetitive motion injury (RMI) or cumulative trauma disorder (CTD). Typically these injuries were caused by repetitive motions, such as of a hand, and there was a cumulative effect so that RMI might develop after an extended period of time (McKeown, 2008). Table 3 shows the JHA for maintaining crops process for further understanding.

3.4 Fourth process – Harvesting

Figure 4: A Worker Using Sharp Object (Sickle or Machete) to Cut Pineapple Fruit from its Tree

Fig. 4 shows a worker was harvesting pineapple fruit by using sharp sickle or machete. Harvesting pineapples required the workers to use sharp objects to cut off the fruit from its tree. Therefore, it involved awkward posture of the trunk area and forceful exertion while performing task using shoulders, arms, wrists and hands. After cutting the fruit, workers then required to put them into a knapsack basket until the basket was full. The minimum weight of full knapsack basket with fruits was 50 kilograms and if modified, the basket could carry up to 70 kilogram per session and this would go for more than four hours in a day total up to 500 to 600 kg of fruits per day. Pineapples were planted on a hilly terrain peat soil, causing the workers to work on unstable base of land.

A study by Pope et al. (2003) revealed a correlation between workers whose jobs required lifting moving objects heavier than 23 kg with lower back discomfort along with hip discomfort. Also, study by Rani et al. (2016) found that harvesting pineapples was the task with the highest rating hazard as the knapsack basket was too heavy and exceeded the safe limit and ideal lifting load. Furthermore, an investigation of back pain among agricultural workers by Sukadarin et al. (2016) revealed that upper back and lower back discomfort usually happened due to repeated activities, twisting motion, poor posture and overuse of muscles or due to injuries received while engaging in heavy physical activities. Table 4 shows the JHA for the last process in pineapple plantation which is harvesting.

Table 4: JHA for Harvesting

Main Process	Sub process	Ergonomics risk factors	Criterion	Possible consequences	References	Recommended controls
Harvest	Cutting and collecting	High exertion force	Forceful exertions of shoulder, arm, wrist, and trunk	Shoulder disorders	NIOSH (1997); Rosecrance et al. (2006); Lee (2016)	Use adjustable and suitable tools to cut the fruit to shorten the reaching distances.
		Highly repetitive hand motion	Deviation and twisting of wrist from neutral position repetitively (more than 20 times per minute)	Hand/wrists pain Hand/wrist tendonitis	Sukadarin et al. (2014); Swangnetr et al. (2014); Buckle & Jason Devereux (2002)	Redesign tools or equipment to enable neutral postures
		Prolonged stooping	Excessive bending during unloading the pineapple to the ground (more than 60°)	Low back pain	Reid et al. (2010); Sukadarin et al. (2016)	Adapt neutral postures
	Transport to pack house	Heavy and awkward lifting	Carry heavy load during working hours (50 to 70 kilogram per session), total 500-600 kg in a day		Koltan (2009); (Govindu & Babski-reeves (2014); Kuta, Cież, & Młotek (2015)	Reduce the weight load to limit force exertion Cultivate teamwork skills to lift heavy objects Encourage proper body mechanics and use safety lifting techniques

4.0 CONCLUSION

Job hazard analysis was conducted to assess ergonomics risk factors in Malaysian pineapple plantation. The prominent part of body affected was at the lower extremities as working in a pineapple plantation demanded workers to constantly use their lower extremities. The eminent risk factors were poor postures and heavy lifting. Poor postures included were squatting, kneeling and stooping.

This study suggested that pineapple plantation workers were exposed to various ergonomics risks which could contribute in developing of MSS. The observation found that ergonomics risk was one of the main hazards in pineapple plantation regarding on the safety and health issue. Some of the highlighted risks during preliminary study were heavy lifting, highly repetitive motion in lower extremities, stooping, squatting, kneeling and bending. There were considerable high risks of poor and awkward posture as well as prolonged time exposure. The tasks which also were described as labour intensive and physically demanding present forceful exertion and heavy lifting.

Appropriate ergonomics programmes such as expert's support, training and education were necessary to reduce the prevalence and to prevent the risk of exposure to MSS among these workers. Besides, ergonomics intervention design should also take place in order to reduce the exposure. To achieve successful mechanization design of tools or equipment, the involvement of workers is essential. Their opinion and interpretation is crucial as most agricultural workers often play the primary role of identification, refinement and conformity on tools and equipment.

ACKNOWLEDGEMENT

Special gratitude is addressed for the participations in the whole JHA program which involved the management staff and aborigine workers of Ladang Bersepadu Nanas Rompin Pahang (Malaysian Pineapple Industry Board). This project is financially funded by the grant Ministry of High Education of Malaysia (Knowledge Transfer Programme) (Grant Number: RDU161002). A special appreciation also goes to Universiti Malaysia Pahang (www.ump.edu.my) for the support in term of facilities and expertise.

REFERENCES

Abrahao, R.F., Gonzaga, M.C., Frederico, R.C., Tereso, M.J.A, (2017). Personal Protective Equipment Design and Ergonomics Work Analysis : Protecting Farm Pineapple Growers. *Proceedings of The 2nd Asian Conference on Ergonomics and Design*, **53**, 552–555.

Andersen, J.H., Haahr, J.P., Frost, P., (2007). Risk factors for more severe regional musculoskeletal symptoms: A two-year prospective study of a general working population. *Arthritis Rheu,* **56** (4), 1355-1364.

Balasubramanian, V., Adalarasu, K. & Regulapati, R., (2009). Comparing dynamic and stationary standing postures in an assembly task. *International Journal of Industrial Ergonomics*, **39** (5), 649-654.

Buckle, P.W. and Jason Devereux, J., (2002). The nature of work-related neck and upper limb musculoskeletal disorders. *Applied Ergonomics*, **33**, 207–217.

Chao, E.L., Henshaw, J.L., (2002). Job Hazard Analysis. OSHA Publication 3071 (Revised). Occupational Safety and Health Administration, US Department of Labor, Washington.

Chung, M.K., Lee, I., Kee, D., (2003). Assessment of postural load for lower limb postures based on perceived discomfort. *International Journal of Industrial Ergonomics,* **31**, 17–32.

Chung, M.K., Lee, I., Kee, D., (2005). Quantitative postural load assessment for whole body manual tasks based on perceived discomfort. *Ergonomics* **48** (5), 492–505.

Cooper, C., McAlindon, T., Coggon, D., Egger, P., Dieppe, P., (1994). Occupational activity and osteoarthritis of the knee. *Ann Rheum Dis*, **53**(2):90–3.

Das, B. and Gangopadhyay, S., (2011). An ergonomics evaluation of posture related discomfort and occupational health problems among rice farmers. *Occupational Ergonomics*, **10** (1–2), 25–38.

Davis, K.G., Kotowski, S.E., (2007). Understanding the ergonomics risk for musculoskeletal disorders in the United States agricultural sector. *Am J Ind Med*, **50**, 501−511.

Department of Occupational Safety and Health Malaysia. (2008). *Guidelines for Hazard Identification, Risk Assessment and Risk Control*.

Earle-Richardson, G., Jenkins, P.L., Slingerland, D.T., Mason, C., Miles, M., May, J.J., (2003). Occupational injury and illness among migrant and seasonal farm workers. *Am. J. Ind. Med*, **44** (1), 37- 45.

Fathallah, F.A., (2010). Musculoskeletal disorders in labor-intensive agriculture. *Applied Ergonomics*, **41**(6), 738–743.

Genaidy, A.M., Al-Shedi, A.A., and Karwowski, W., (1994). Postural stress analysis in industry. *Applied Ergonomics*, **25**(2), 77–87.

Govindu, N. K., and Babski-reeves, K., (2014). International Journal of Industrial Ergonomics Effects of personal, psychosocial and occupational factors on low back pain severity in workers. *International Journal of Industrial Ergonomics*, **44** (2), 335–341.

Guo, Y., Wang, B., Lee, C., and Wang, J., (1996). Prevalence of dermatoses and skin sensitisation associated with use of pesticides in fruit farmers of southern Taiwan. *Occupational And Environmental Medicine*, **53**, 427–431.

Heather, L.B., and John, W.K., (2003).The effect of load and posture on load estimations during a simulated lifting task in female workers. *Int. J. Ind. Ergonomics,* **31**(5), 331-341.

Juul-Kristensen, B., and Jensen, C., (2005). Self- reported workplace related ergonomics conditions as prognostic factors for musculoskeletal symptoms: the "BIT" follow up study on office workers. *Occupational and Environmental Medicine*, **62** (3), 188-194.

Kirkhorn, S.R., and Schenker, M.B., (2002). Current health effects of agricultural work:respiratory disease, cancer, reproductive effects, musculoskeletal injuries, and pesticide-related illnesses. *J. Agric. Saf. Health*, **8** (2), 199-214.

Koltan, A., (2009). An ergonomics approach model to prevention of occupational musculoskeletal injuries. *International Journal of Occupational Safety and Ergonomics*, **15**, 113–124.

Kuta, Ł., Cież, J., & Młotek, M., (2015). Musculoskeletal load assessment of farmers during selected agricultural works. *Procedia Manufacturing*, **3**, 1696–1703.

Lee, T., (2016). The effects of arm posture and holding time on holding capability and muscle activity. *International Journal of Occupational Safety and Ergonomics (JOSE)*, 1–5.

Maity, P., De, S., Pal, A., Dhara, P.C., (2016). An experimental study to evaluate musculoskeletal disorders and postural stress of female craftworkers adopting different sitting postures. *International Journal of Occupational Safety and Ergonomics*, **22**(2), 257–266.

McKeown, C., (2008). A Guide to Human Factors and Ergonomics. *Ergonomics*, **51**(6), 949-951

Meyer, R.H., Radwin, R.G., (2007). Comparison of stoop versus prone postures for a simulated agricultural harvesting task. *Applied Ergonomics,* **38**, 549–555.

Messing, K., Tissot, F., Stock, S.R., (2006). Lower Limb Pain, Standing, Sitting,Walking: The Importance of Freedom to Adjust One's Posture. The International Ergonomics Association, Maastricht, Netherlands.

National Institute of Occupational Safety and Health (NIOSH). (1997). Musculoskeletal disorders and work- place factors (Publication No. 97–141). Cincinnati, OH: Department of Health and Human Services.

Ngomo, S., Messing, K., Perrault, H., Comtois, A., (2008). Orthostatic symptoms, blood pressure and working postures of factory and service workers over an observed workday. *Applied Ergonomics* **39** (6), 729–736.

Occupational Safety and Health Administration (OSHA 3071), (2002) (Revised). Job hazard analysis. *US Department of Labor*, 1–46.

Osborne, A., Blake, C., Fullen, B.M., (2012). Prevalence of musculoskeletal disorders among farmers: A systematic review. *Am J Ind Med*, **55**, 143−58.

Pope, D.P., Hunt, J.M., Birrell, F.N., Silman, A.J., Macfarlane, G.J., (2003). Hip pain onset in relation to cumulative workplace and leisure time mechanical load: a pop- ulation based case-control study. *Annals of the Rheumatic Disease,* **62**, 322–326.

Rani, N.H., Abidin, E.Z., Ya'acob, N.A., Karuppiah, K., (2016). Musculoskeletal Symptoms Risk Factors and Postural Risk Analysis of Pineapple Plantation Workers in Johor. *Journal of Occupational Safety and Health*, **13**(1), 17–26.

Reid, C. R., Mc Cauley Bush, P., Karwowski, W., Durrani, S.K., (2010). Occupational postural activity and lower extremity discomfort: A review. *International Journal of Industrial Ergonomics*, **40**(3), 247–256.

Rosecrance, J., Rodgers, G., Merlino, L., (2006). Low back pain and musculoskeletal symptoms among Kansas farmers. *Am J Ind Med*, **49**, 547−56.

Scuffham, A.M., Legg, S.J., Firth, E.C., Stevenson, M.A., (2010). Prevalence and risk factors associated with musculoskeletal discomfort in New Zealand veterinarians. *Appl. Ergon*. **41**(3), 444-453.

Steven R. Kirkhorn, Giulia Earle-Richardson, R.J. Banks, C., (2013). Ergonomics Risks and Musculoskeletal Disorders in Production Agriculture : Recommendations for Effective Research to Practice, *Journal of Agromedicine*, **15**(3), 281-299

Sukadarin, E.H., Deros, B.M., Ghani, J.H., Ismail, A.R., (2014). A review of work related musculoskeletal problems in agricultural industry. *Aust. J. Basic & Appl. Sci.,* **8**(19), 56-59.

Sukadarin, E. H., Md Deros, B., Mohd Nawi, N. S., A. Ghani, J., Ismail, A. R., and Zakaria, J., (2016). Back Pain and the Observed Factors among Oil Palm Workers. *International Journal of Engineering Technology and Sciences,***5**, 70–78.

Swangnetr, M., Kaber, D. B., Puntumetakul, R., and Gross, M.T., (2014). Ergonomics-related risk identification and pain analysis for farmers involved in rice field preparation. *Work (Reading, Mass.)*, **49**(1), 63–71.

Tamrin, S.B.M., and Aumran, N., (2014). *A comparison of the hazards, the risks, and the types of control in three selected agricultural industries*. Occupational Safety and Health in Commodity Agriculture :Case Studies from Malaysian Agriculture Perspective , **1**, 93–146.

Thambyah, A., Goh, J.C.H., De, S.D., (2005). Contact stresses in the knee joint in deep flexion. *Medical Engineering and Physics*, **27**, 329–335.

Walker-Bone, K., Palmer, K.T., (2002). Musculoskeletal disorders in farmers and farm workers. *Occup Med*, **52**, 441−50.

Zadry, H.R., Dawal, S.Z.M., Taha, Z., (2011). The relation between upper limb muscle and brain activity in two precision levels of repetitive light tasks. *International Journal of Occupational Safety and Ergonomics*, **17**, 373–384.