

Investigation of protective clothing used against pesticides in agriculture

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Pesticides are chemical mixtures that are used to destroy, control or reduce harmful organisms and they toxic to humans. Pesticides enter the body through the mouth, respiration and skin and most of them can show carcinogenic, mutagenic, allergic and irritant effects. These harms can be prevented by the protective measures to be taken by workers when using pesticides in agricultural areas. This study investigated the working conditions of greenhouse workers and the protective clothing they should wear to protect themselves from pesticides. In the first part of the study, a face-to-face questionnaire was applied to 83 people working in greenhouses in different regions were asked about their work clothing using a personal questionnaire. In the second part, disposable protective clothing of 2 different brands that are widely used in the sector, were examined. These products were compared in terms of sewing properties and model properties. As a result of the survey, it was stated that 87% of the workers in the greenhouses wear work clothes, wash their clothes in the machine, mostly every 2 days, and change the clothes when the period of use is over. 80% of them were satisfied with their work clothes, and they listed their expectations from the clothes such as protection against harmful chemicals, being suitable for the work environment, being liquid proof and being comfortable. It has been determined that it is very important to inform agricultural workers about pesticides through training programs to protect and improve their health.

Keywords: Protective clothing; Environment; Health; Work cloth; Pesticide

Stručni rad

Ispitivanje zaštite od pesticida radne (zaštitne) odjeće radnika u poljoprivredi

Pesticidi su kemijske tvari koje se koriste za uništavanje, kontrolu ili smanjenje štetnih organizama i otrovne su za ljude. Pesticidi ulaze u tijelo kroz usta i kožu te disanjem, a većina njih može pokazati kancerogeno, mutageno, alergijsko i nadražujuće djelovanje. Štetnost se može spriječiti zaštitnim mjerama koje moraju poduzeti radnici prilikom korištenja pesticida u poljoprivrednim područjima. U ovom su radu ispitani radni uvjeti radnika u stakleniku i zaštitna odjeća koju bi trebali radnici nositi za zaštitu od pesticida. U prvom dijelu rada, anketni upitnik u direktnom kontaktu (face-to-face) ispunilo je 83 radnika koji rade u staklenicima u različitim regijama, a pitanja su bila vezana uz uvjete rada i osobna iskustva u primjeni zaštitne odjeće. Upitani su o radnoj odjeći pomoću osobnog upitnika. U drugom dijelu rada je ispitana jednokratna zaštitna odjeća dvije različite robne marke koje se najviše koriste u ovom sektoru. Ovi su proizvodi uspoređivani u pogledu svojstava šivanja i svojstava modela. Kao rezultat ankete utvrđeno je da 87% radnika u staklenicima nosi radnu odjeću, peru odjeću u stroju, uglavnom svaka 2 dana, te mijenjaju odjeću nakon isteka roka trajanja. Njih 80% bilo je zadovoljno svojom radnom odjećom, a u svojim očekivanjima o svojstvima odjeće naveli su zaštitu od štetnih kemikalija, prikladnost za radno okruženje, otpornost na tekućine i udobnost. Utvrđeno je da je vrlo važno informirati poljoprivredne radnike o pesticidima kroz programe poučavanja kako bi zaštitili svoje zdravlje.

Ključne riječi: zaštitna odjeća; okoliš; zdravlje; radna odjeća; pesticidi

1. Introduction

With population growth, the areas used as agricultural lands are decreasing and these areas are being replaced by industrial facilities. This puts great pressure on producers to get more efficiency from already limited agricultural areas. In order to meet the food needs of the increasing population, modern agricultural techniques and inputs need to be used to increase the yield and quality of agricultural products. One of the most commonly used methods of combating pests in agriculture is the use of pesticides. The average loss in agricultural production caused by diseases, pests and weeds varies between 20 and 40%. These losses continue during the harvesting, drying, storage and processing stages. Approximately 20% of world grain production is lost in the pre- and post-harvest stages. Pesticides reduce the damage of diseases, harmful insects and weeds, as a result, production increases, quality increases and economic return increases [1].

Pesticides are chemical mixtures used to destroy, control or reduce the damage of harmful organisms [2]. The term pesticide means algicide (algae killer), avicide (bird killer), bactericide (bacteria killer), fungicide (fungus killer), herbicide (weed killer), insecticide (insect killer; ovidicide (egg killer), larvicide (larva killer). It covers all chemicals that can be listed as adulticide (adult killer), acaricide (mite killer), molluscicide (slug and snail killer), nematocide (nematode killer), rodenticide (rodent killer) and virucide (virus killer) [3].

In fact, the use of pesticides in agricultural control should be the last thing to consider. However, it is primarily preferred by farmers due to its features such as being effective in a short time, ease of application, being economical when used correctly and increasing the yield and quality of the product [4].

Pesticides are by their nature potentially toxic to other organisms, including humans (WHO). For this reason, everyone who uses pesticides should avoid the harm that may occur during their use [5, 6].

When the effects of pesticides on human health are examined; the harm that chemical plant protection and plant nutrition products used in agriculture cause to human health and the environment is becoming better understood every day. [7]. Some of the producers, with their unconscious chemical control practices against agricultural pests, not only increase the amount of input unnecessarily, but also cause negative effects that pose a threat to the environment and human health [8]. In the classification made by the World Health Organization, of the approximately 700 most commonly used pesticides, 33 are very harmful to human health, 48 are quite hazardous, 118

are moderately hazardous and 239 are less hazardous [9,10].

Exposure to pesticides occurs during pesticide production, transportation, storage, use, and consumption of products containing pesticide residues. Pesticides enter the body through mouth, breathing and skin.

Most pesticides can have carcinogenic, mutagenic, allergic and irritating effects [11]. There are many methods to minimize the effects of pesticides on humans during agricultural production. The most important of these methods is the use of necessary protective clothing and equipment.

Protective clothing is technical textile products used to prevent and/or reduce the risk of the person being exposed to harmful substances and bad environmental conditions [12]. The features of these garments vary according to the requirements of the industry in which they are used.

Protective clothing is technical clothing that acts as a buffer between the wearer and the potential risk source, stands out with its technical features rather than its aesthetic and visual features, and is produced to protect the health of the wearer. These clothes, which are used by people working in various risk environments to protect them and minimize the risk they will be exposed to, are increasingly given importance within the scope of occupational health [13].

The fact that the temperature and humidity in greenhouses are high and the most of pesticides remain suspended in the air after use further increases the harmful effects of pesticides on human health. Therefore this study examined the working conditions of greenhouse workers and the protective clothing they should wear to protect themselves from pesticides. There are various studies on this topic.

The following studies were found in the literature review on this topic. Önen, C. *et al.* [14] investigated the protective measures used by farmers in Adıyaman Çelikhhan district during the agricultural spraying process. They found that farmers mostly use pesticide face masks and gloves as personal protective equipment, most of them do not eat/drink during spraying, and half of them dispose of pesticide materials safely. Rani, P. *et al.* designed protective clothing and accessories to overcome occupational health risks for farmers exposed to pesticides and organic dusts, and then tested the suitability and acceptability of these products [15].

İşıktekin, A.B. *et al.* [16] aimed to determine the protective behavior of seasonal agricultural workers against pesticide exposure in their study. They concluded that seasonal agricultural workers do not receive the necessary training on the safe use of

pesticide and that their behavior is not sufficient to protect them from pesticide exposure and that training programs should be organized to ensure that agricultural workers acquire safe pesticide use behaviors and to protect and improve their health.

Boorady, L.M. *et al.* aimed to conduct a multi-method field analysis on one type of protective clothing and showed the improvements that would result from changes to the design of this clothing [17].

In their study, Machera, K. *et al.* [18] examined the performance of two overall designs used by pesticide applicators. Two types of protective suits (overalls) were selected based on data from previously conducted comfort tests under field conditions in Southern Europe. Skin exposure was measured during 22 applications carried out by 11 operators applying pesticides with hand-held spray guns to pepper crops grown in the greenhouse in the Lerapetra region of Crete Island, Greece.

In his study, Yaday, S. [19] distributed brochures, watched video films and explained the use of protective clothing in order to raise awareness about protective clothing among agricultural workers in the Hisar Region, so that they recognize the health hazards they are exposed to without protective clothing. The change in the awareness of those who had participated in this event was also examined.

2. Materials and methods

2.1. Materials

The material in this study consists of data from the survey applied to workers working in greenhouses in the Marmara, Aegean and Mediterranean Regions and disposable protective clothing of two different brands frequently used against chemicals in greenhouses.

2.2. Methods

The research consists of 2 phases. In the first part, a personal interview was conducted with 83 people working in greenhouses in different geographical regions in Turkey about the work clothes they wear, and the data from these surveys were evaluated in the SPSS 25.0 package program. In the second part of the study, disposable protective clothing from two different brands that are widely used in the industry were examined. These products were compared in terms of their sewing and model characteristics.

3. Results and Discussion

As a result of the application of the survey, the following data was obtained.

3.1. Working environment

94% of the participants work in the greenhouse and 6% in the warehouse (Fig.1).

3.2. Daily working time

While 47% of the survey participants work 6-8 hours a day, 53% of the survey participants work 8-10 hours a day (Fig.2).

3.3. Risks of the working environment

In this question, where more than one option can be marked, 49.4% of respondents stated that temperature is a risk, 24.4% stated that the humidity is a risk, 10.2% stated that there is a possibility of insect and fly bites, 14.3% stated that there is a possibility of poisoning from pesticides and 1.8% stated that the machines used is a risk (Fig.3).

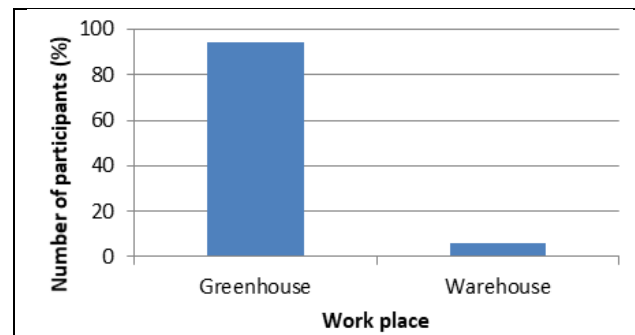


Fig.1 Characteristics of the working environment

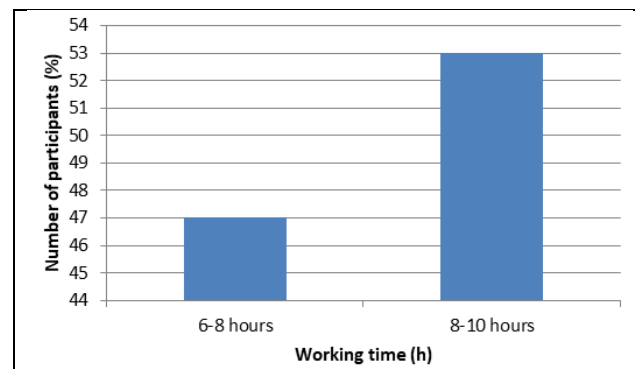


Fig.2 Daily working time

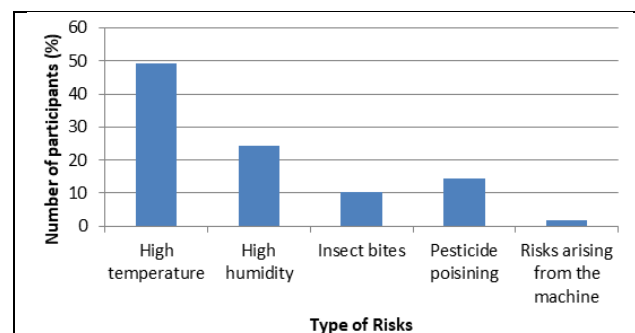


Fig.3 Risks of the working environment

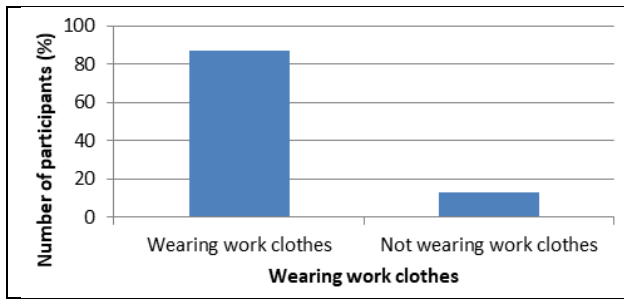


Fig.4 Rate of wearing work clothes while working

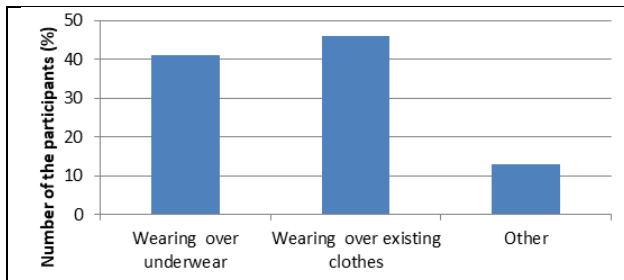


Fig.5 Answers to *How to wear work clothes?*

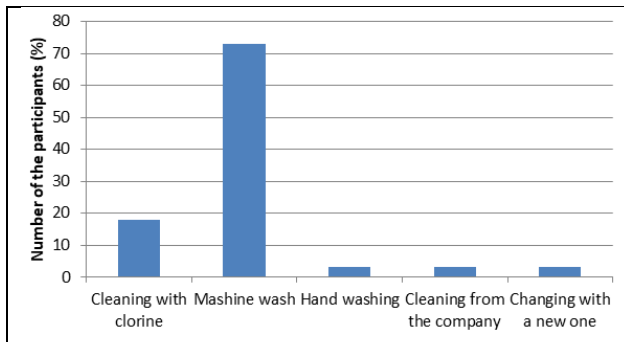


Fig.6 Answers to *How to clean work clothes?*

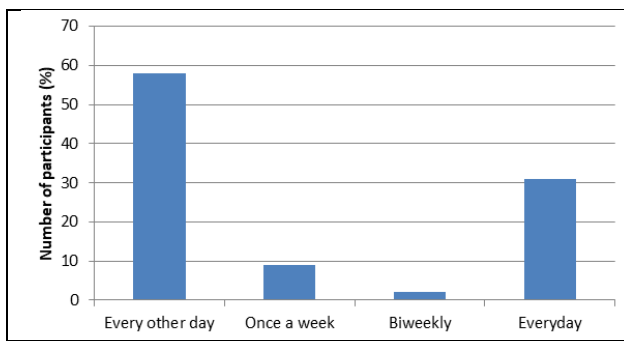


Fig.7 Frequency of cleaning of work clothes



Fig.8 Renewal of protective clothing and personal protective equipment

The fact that 14.3% of workers think about the possibility of poisoning from pesticides shows that they are aware of the use of pesticides.

3.4. Rate of wearing work clothes while working

87% of the respondents use work clothes while working, and the remaining 13% do not use work clothes (Fig.4). It is very important to raise awareness of people who do not use work clothes and encourage them to use them.

3.5. How to wear work clothes

While 41% of employees wear their work clothes over their underwear, 46% wear their work clothes over their existing clothes. 13% of the survey participants selected "other" option (Fig.5). Whether the workwear will be worn in summer or winter and its model feature also affect the way it is worn. The important thing is to use protective clothing during work.

3.6. Cleaning of the work clothes

While 18% of respondents clean their work clothes with chlorine, 73% clean them by machine and 3% by hand (Fig.6). The remaining 3% stated that their clothes were cleaned by the company they work for. Only 3% of respondents stated that they change their workwear when it is no longer valid (Fig.6).

3.7. Frequency of cleaning of the work clothes

From Fig.7 it can be seen that 58% of the survey participants clean their work clothes every two days, 9% clean them once a week, 2% clean them every two weeks, and 31% clean them every day. When reusable work clothing is used, it is of great importance to clean it from any drug residues that may form on it. Therefore, it must be cleaned with appropriate cleaning agents within the required time.

3.8. Renewal of protective clothing and personal protective equipment

77% of the survey participants renew their protective clothing and personal protective equipment when their use expires, 12% every month, 7% every six months, and 3% every year (Fig.8).

In reusable work clothes, the clothes will lose their efficiency of protection as they are used and cleaned. For this reason, the clothing renewal period must be determined by taking into account the characteristics of the fabric.

3.9. Satisfaction status of protective clothing

80% of the survey participants stated that they were satisfied with the work clothes they used. 15.4% of the reasons for satisfaction are that it is easy to maintain, 24.6% is that it is comfortable, 36.9% is that it is suitable for health and safety, and 23.1% is that it protects against the effects of the working environment (Fig.9). Satisfaction or dissatisfaction with work uniform is a very important factor for the employee's work motivation.

20% of the survey participants stated that they were not satisfied with the work clothes they used. Reasons for dissatisfaction include 29.4% that is restricts their movement at work (Fig.10), 44.1% that the fabric is being thick and hard, 17.6% that is not suitable for the work done and 8.9% that it does not provide protection against harmful substances.

3.10. Protective clothing and personal protective equipment used in the workplace

87% of the survey participants stated that they used protective clothing and personal protective equipment in the spraying environment, and 13% stated that they did not use any personal protective clothing or equipment. The majority of those who do use protective clothing and personal protective equipment, namely 42.6% only use gloves as personal protective equipment. Of the remaining, 23.9% use masks, 9.7% use hats, 9.1% use overalls, 7.9% use aprons and 6.8% use goggles. Among the answers given in the survey were bonnets, boots, galoshes and scarves (Fig.11).

Personal protective equipment is as important as workwear. Personal protective equipment should be given as much importance as work clothes in order to protect the parts of the body other than work clothes against pesticides and harmful chemicals.

3.11. Fabric structure of the protective clothing used

50% of the survey participants stated that the protective clothing they use is cotton/polyester. The remaining 31% stated that their clothes were cotton. 19% of the survey participants selected "the other" option (Fig.12). While 57% of the respondents change their protective clothing according to the seasons, 47% do not change it according to the season.

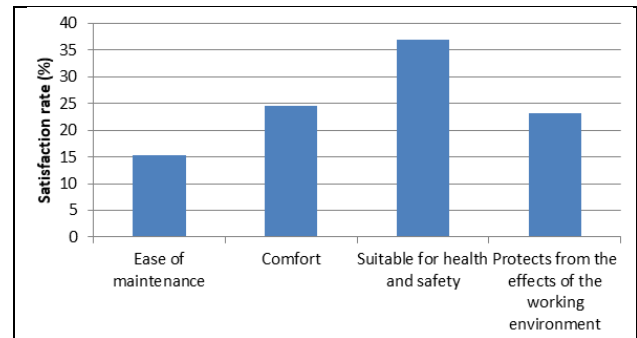


Fig.9 Satisfaction status of the work clothes

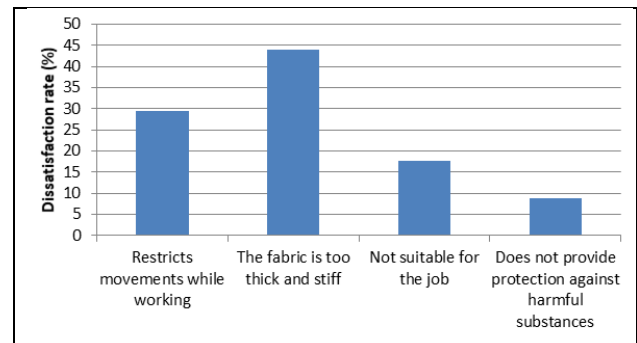


Fig.10 Dissatisfaction with the work clothes

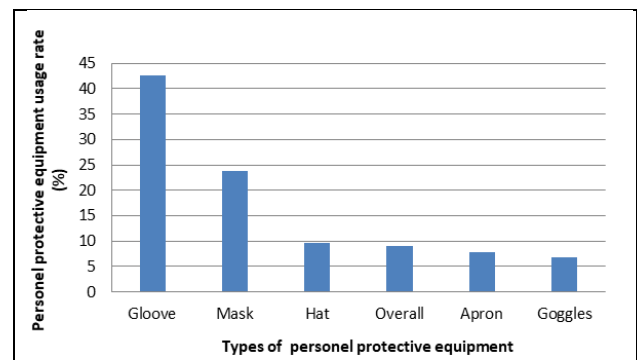


Fig.11 Personal protective equipment used in the workplace

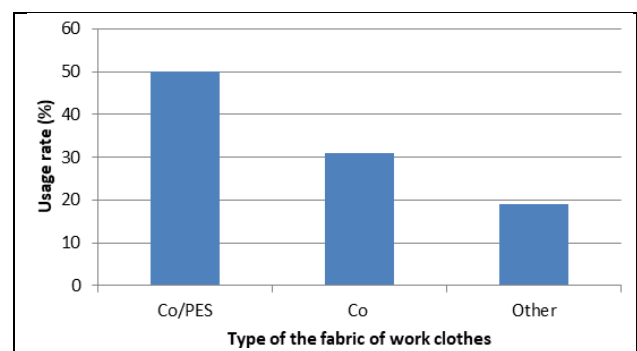


Fig.12 Fabric composition in the work clothes

3.12. Expectations from the protective clothing

Although the expectations of people working in greenhouses differ in terms of the protective clothing and personal protective equipment they use the hazards they are exposed to in the working environment are similar.

Tab.1 Comparison of model features of protective clothing from 2 different brands

	A	B
Type of stitching on wrists and ankles	3 thread overlock	3 thread overlock
Wrist and ankle circumference	Wide	Narrow
Seam	Inside the clothes	Outside the clothes
Zipper (throughout the garment)	Long	Long
Zipper flap	Not exist	Exist
Hood with elasticated edges	Exist	Exist
Waist elastic	Loose	Tight
Label	Joining with overlock stitching	Joining by Silicone

Based on the survey respondents' expectations of protective clothing can be listed in order of importance as follows:

- protection against harmful chemicals,
- suitable for the working environment,
- no liquid spills,
- being comfortable,
- masks are odorless and breathable,
- suitable for the season,
- robust and durable,
- do not hinder movement while working,
- being affordable,
- no staining.

According to the data from a personal survey of greenhouse workers, most of them wear reusable work clothes. The obtained data showed that the protective properties of this clothing are poor. Therefore, the second part of the study, examined disposable protective clothing from two different brands that offer better protection against pesticides and are widely used in the market.

3.13. Comparison of model features

In Table 1 the model characteristics of protective clothing from two different brands are compared. Both products are made of non-woven fabric and are disposable.

The elastic at the wrists and ankles is tighter on brand B protective clothing than that of brand A. Therefore, brand A is more likely to leak in contact with liquid.

The seams of both products are joined with 3 thread overlock. The seams of brand B protective clothing are on the outside of the product, while the seams of brand A protective clothing are on the inside. As both garments are disposable, it make no difference to the wearer whether the seams are on the inside or outside.

In both products, long zippers starting from the neck level are used to make the product easy to wear. However, the zipper length on brand B protective clothing is longer than the zipper length on brand A's clothing. This means that brand B protective clothing

is more comfortable in that it is easier to put on and take off.

The brand B protective clothing has a zipper flap, unlike model A. This is very important in preventing liquid from entering the garment through the zipper seams. Both models have a hood with an elasticated edge. Elastic waistband is used in both products. However, the elastic on the waist of brand B protective clothing is tighter than the elastic on the waist of brand A. This allows brand B clothing to fit better on the wearer's body.

While the label was added to brand B protective clothing by welding method, it was attached to brand A clothing by overlocking. If the garment is worn over underwear, labels attached with overlock can irritate the wearer's skin.

4. Conclusion

The use of pesticides is inevitable in today's modern agriculture. However, when using pesticides, both the protection of the product against diseases, pests and weeds and the negative effects on humans and the environment should be evaluated together. There is particularly high risk of pesticide exposure to pesticides for those who apply pesticides and for agricultural workers who work in pesticide-treated areas. Since the hazards exposed to in different lines of work are different, the choice of work clothing is of great importance for human health. It is necessary to choose the appropriate fabric raw material and fabric production technique depending on the season, the work to be done, and whether it is disposable or reusable. Finishing processes can be applied to the fabrics depending on the desired properties (for example, antibacterial finishing process).

In addition to its protective features, work clothes are also important for the wearer to feel comfortable and work comfortably. For this reason, along with the fabric feature of the garment, pattern comfort, correct joining technique, and correct closing methods are also issues that need to be considered.

Contaminated clothing is a significant problem in pesticide exposure. Workers working in environments where pesticides are used must wear appropriate protective clothing, and if they are reusable, these clothing must be cleaned regularly and safely and replaced at the end of the period of use.

It is of great importance to ensure that agricultural workers acquire safe pesticide use behavior and to inform people about pesticides by organizing training programs to protect and improve their health.

Protective clothing with the appropriate level of protection to be used is disposable.

Therefore, constantly renewing disposable clothing will be costly for employees. As can be seen from the data obtained from the survey, employees either wear reusable clothing provided by the employer or work with their own daily clothes. Therefore, in order to protect the health of their employees, employers must guide their employees correctly in the use of protective clothing and support them in providing clothing.

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