

A Design for Summer Safety Shoes for Agricultural Work Using a Survey

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Received : November 06, 2014

Revised : December 05, 2014

Accepted : May 19, 2015

Objective: This study aimed to find good design for summer functional farm shoes under the agricultural environment and working characteristics, which can help safe farm work and further promote the efficiency of working.

Background: Most accidents at farms were overturn accidents caused by slipping or falling, and it was found that the main factors which caused the overturn accidents were inappropriate work shoes for the working conditions. These inappropriate work shoes often cause overturn accidents in the rural areas with steep paths.

Method: A survey on work shoes was conducted with 174 farmers, and the outcome of this survey was used to find problems of work shoes and improvement ideas for the design of work shoes which can be used at farms.

Results: Regarding the form of farm shoes, the ankle height was set at 6 inches to prevent the bending of the ankle and the inflow of foreign substances. The size and groove of the pattern of the outsole were extended to prevent catching of foreign substances. In the upper part, polyurethane and cordura were used in combination to secure air permeability, which was pointed out as the reason for the discomfort during the work wearing existing work shoes.

Conclusion: Since farmers felt discomfort with the shoes which they were currently wearing, this study suggested a design of farm shoes by analyzing the important matters of the work shoes in development in order to improve such discomfort.

Application: This study can help develop farm shoes that would practically ease farmers' burden of working at farm worksites and keep them safe.

Keywords: Agricultural work shoes, Farmer, Summer shoes, Design

1. Introduction

The foot is recognized as a very important human body part, which can be called the second heart. Because the whole response points of human body are gathered on the sole of one's foot, the foot health is closely related with human body health. Especially, the foot plays a role of supporting and propelling human body, and therefore, it directly affects human body activity efficiency. Shoes should protect our feet from external dangers, prevent pollution, ease shock during the work, and help smooth walking.

Nowadays, farmers tend to be exposed to physical and chemical harmful factors

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including ultraviolet rays, dust and agricultural chemicals that can affect health, while they work, and also to ergonomic risk factors such as heavy stuff carrying or squatting. One of the efforts that an individual can make to reduce such harmful risks is to wear protective gear. Safety shoes or work shoes are to protect feet from physical and chemical danger factors that can be caused in worksites, and they can be the most basic equipment to keep individual safety. While most workers wear safety shoes in general industrial sites, since wearing of those shoes is compulsory, not many farmers wear the shoes suitable for working characteristics. As such a result is reflected, the damage type that occurs most in relation with agricultural work is overturn accident, such as slipping or tripping, with 26,049 cases in 67,835 cases of injury, according to disease and damage survey result on farmers during work (Korean Statistical Information Service, 2013). Especially, about half of female farmers were surveyed to experience overturn accidents. Wearing shoes not suitable for work and purpose in the rural area life and working environment such as not only worksite, but pedestrian facility can induce overturn accidents like slipping, tripping or false step, unlike urban area.

Examining preceding studies related with work shoes, there are following studies: a study evaluating the weight, slipperiness, tear strength of safety shoes used by cooking employees and presenting the standard values to develop shoes suitable for kitchen environment, where cooking employees work (Oh, 2009), a study classifying safety shoes used in Korea, according to outsole type, and analyzing the effects of outsole characteristics on resistance to slipperiness (Choi, 2008), a study analyzing the effects of steel toecap on the pressure of sole within the safety shoes (Park, 2008), and a study on safety shoes design to improve functionality (Lee, 2006). These studies target the safety shoes worn by workers at general industrial sites who work on mainly even and flat floor. Even the studies on agricultural work shoes are mostly about the types of work shoes worn by farmers or work burden, according to shoes heels (Lee and Choi, 1996a; Lee and Choi, 1996b). In view of Korea's agricultural work characteristics, load to feet is huge, due to squatting position, etc., and the transformation of and damage to feet are frequently observed. Actually, studies on the development of agricultural work (safety) shoes are insufficient.

This study aims to suggest the design of agricultural work shoes by investigating the reality of summer work shoes targeting 174 farmers, and by identifying the problems and improvements of the work shoes currently worn in order to develop agricultural work shoes reflecting agricultural environment and work.

2. Method

2.1 Subjects

174 farmers from Gyeongbuk, Jeonbuk, Gangwon and Gyeonggi provinces participated in the questionnaire survey.

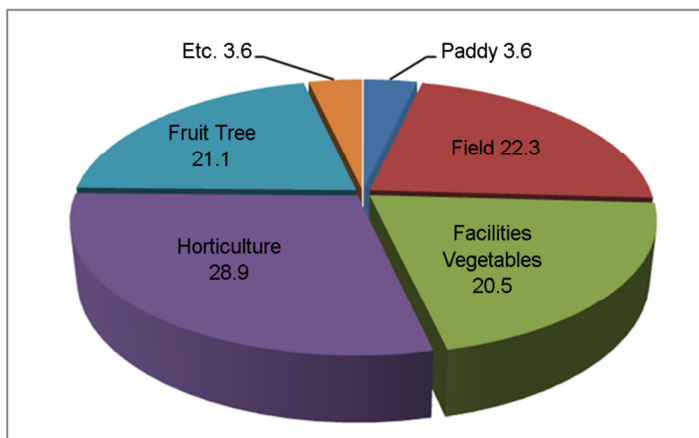
Table 1 shows the general characteristics of the subjects in this study. Of those 174, males were 129 people (74.1%), higher than 45 females (25.9%). As for age, those in their 50s were most with 60 people or 36.2%, followed by those in their 40s with 44 or 25.3%, 60s with 35 or 20.1%. The aging farmers aged 60 or over were 31.0%: females in their 60s and 70s were 42.2%, and females' aging was remarkable than males. Regarding the career engaged in agriculture, 5 years and less was 99 people and most (56.9%), followed by 25 people with 31 years and over (14.4%). The reason is that the survey was mostly conducted targeting farmers who received education at agricultural technology centers, and returned to agriculture and rural area, rather than through visiting farms. Figure 1 shows main crops cultivated, and horticulture was most with 28.9%, followed by field with 22.3%, fruit tree with 21.1%, and facility vegetables with 20.5%.

2.2 Procedures

This study conducted a questionnaire survey by visiting farms and agricultural technology centers in Gyeongbuk, Jeonbuk, Gangwon and Gyeonggi provinces from June 11 to August 14, 2014. The questionnaire consisted of a total of 22 questions including five

Table 1. Characteristics of respondents (frequency (%))

Age (yr)	Male	Female	Total	Career (yr)	Male	Female	Total
Under 39	11 (8.5)	2 (4.4)	13 (7.5)	Under 5	79 (61.2)	20 (44.5)	99 (56.9)
40~49	32 (24.8)	12 (26.7)	44 (25.3)	6~10	16 (12.4)	5 (11.1)	21 (12.1)
50~59	51 (39.6)	12 (26.7)	63 (36.2)	11~20	12 (9.3)	6 (13.3)	18 (10.3)
60~69	27 (20.9)	8 (17.8)	35 (20.1)	21~30	9 (7.0)	2 (4.4)	11 (6.3)
Over 70	8 (6.2)	11 (24.4)	19 (10.9)	Over 31	13 (10.1)	12 (26.7)	25 (14.4)
Total	129 (100.0)	45 (100.0)	174 (100.0)	Total	129 (100.0)	45 (100.0)	174 (100.0)

**Figure 1.** Main crop cultivated by subjects (%)

questions on general characteristics of the subjects, four questions on summer work shoes, two questions on purchase and 11 questions on discomfort in wearing work shoes. For the questions on discomfort in wearing work shoes, 5-point Likert scale was used: the higher the point was, the lower discomfort was. SPSS 18.0 was used for data analysis, and this study conducted a cross analysis and a *t*-test to compare shoes wearing reality, according to gender, after identifying overall purchase and wearing reality with technical statistics including percentage and mean, centered on variable's frequency.

Prior to the development of agricultural work shoes, this study drew requirements to develop summer agricultural work shoes that improved functionality and activity in consideration of agricultural work characteristics and farmers' life style, based on the preceding studies on agricultural environment and work shoes (Lee and Choi, 1996a; Lee and Choi, 1996b; Kim et al., 2012), and questionnaire survey results. This study selected pattern, design and materials suitable for the requirements, and presented the design of summer agricultural work shoes.

3. Results

3.1 Questionnaire survey

Table 2 shows the survey results of shoes purchase and wearing reality in the case of summer agricultural work. As for the shoes

mainly worn during agricultural work, males wore boots (45.7%), sports shoes (24.8%) and hiking boots (10.8%) in order, and females wore boots (64.4%), sports shoes or new rubber shoes (11.1%, respectively) in order. Although, both males and females wore boots most, the height of the boots showed difference. While males wore calf-height boots, females mainly wore ankle height boots. Purchase places of shoes showed significant difference at 0.001 level. Both males and females purchased boots in the markets most, however, males with relatively wider range of activity, compared with females, purchased boots through various channels including Internet shopping mall or hardware store. The prices of the shoes worn showed significant difference between males and females: males wore KRW 20,000~KRW 50,000 range shoes most with 43.4%, followed by KRW 10,000 range shoes with 31.8%. Females wore KRW 10,000 range shoes most, followed by less than KRW 10,000 shoes. Actually, females wore relatively cheaper shoes than males. This is derived from the difference between males and females in the shoes types. Males are thought to wear relatively higher priced shoes than females in rural area, because males in charge of work, based on labor force, mostly have initiatives in living and economic power. Concerning the reasons preferring the current shoes they wear, the response of wearing shoes comfortably and suitable for work was most for both males and females, followed by the response that the inflow of foreign substances including soil or sand was small.

Table 2. The status of wearing shoes in farm work

		(frequency (%))			
Item		Male	Female	Total	X ²
Type of shoes	Traditional rubber shoes	1 (0.7)	0 (0.0)	1 (0.6)	21.442
	New rubber shoes	6 (4.7)	5 (11.1)	11 (6.3)	
	Slippers	6 (4.7)	2 (4.4)	8 (4.6)	
	Sports shoes	32 (24.8)	5 (11.1)	37 (21.2)	
	Hiking boots	14 (10.9)	3 (6.7)	17 (9.8)	
	Safety shoes	9 (7.0)	0 (0.0)	9 (5.2)	
	Boots	59 (45.7)	29 (64.4)	88 (50.6)	
	Etc.	2 (1.7)	1 (2.2)	3 (1.7)	
	Total	129 (100.0)	45 (100.0)	174 (100.0)	
Place of purchase	Market place	75 (58.0)	33 (73.4)	108 (62.2)	38.387***
	Mart	13 (10.1)	7 (15.6)	20 (11.5)	
	Internet shopping mall	13 (10.1)	1 (2.2)	14 (8.0)	
	Department store	8 (6.2)	1 (2.2)	9 (5.2)	
	Agricultural materials mart	9 (7.0)	1 (2.2)	10 (5.7)	
	Hardware store	5 (3.9)	1 (2.2)	6 (3.4)	
	Etc.	6 (4.7)	1 (2.2)	7 (4.0)	
	Total	129 (100.0)	45 (100.0)	174 (100.0)	
Price	Less than ₩ 10,000	11 (8.5)	13 (28.9)	24 (13.8)	18.840*
	₩ 10000~20000	41 (31.8)	17 (37.8)	58 (33.3)	
	₩ 20001~50000	56 (43.4)	9 (20.0)	65 (37.4)	
	₩ 60000~90000	15 (11.6)	5 (11.1)	20 (11.5)	

Table 2. The status of wearing shoes in farm work (Continued)

		(frequency (%))			
Item		Male	Female	Total	X ²
Price	More than ₩ 100,000	6 (4.7)	1 (2.2)	7 (4.0)	18.840*
	Total	129 (100.0)	45 (100.0)	174 (100.0)	
Reason for selection	Suitable for working with ease	68 (52.7)	22 (48.9)	90 (51.8)	9.066
	Do not become hot	3 (2.3)	0 (0.0)	3 (1.7)	
	Easy to put on and take off the shoes	4 (3.1)	2 (4.4)	6 (3.4)	
	Comfortable	10 (7.8)	2 (4.4)	12 (6.9)	
	Light	1 (0.7)	2 (4.4)	3 (1.7)	
	Easy to maintain, such as laundry or drying	6 (4.7)	4 (8.9)	10 (5.7)	
	Less inflow of foreign substances like soil and sand	31 (24.0)	12 (26.8)	43 (24.8)	
	Etc.	6 (4.7)	1 (2.2)	7 (4.0)	
	Total	129 (100.0)	45 (100.0)	174 (100.0)	

* $p < .05$, ** $p < .01$, *** $p < .001$

As a result of surveying the currently wearing shoes' discomfort with 5-point scale (1 point: not very so, 5 points: very so), significant difference was revealed between males and females in such items as "feet feel hot in working on a hot day", "uncomfortable to wear and take off shoes", "foreign substances including soil and sand go into shoes well". Specifically, males (3.7 points) and females (3.8 points) had many uncomfortable experiences in the item of experiencing discomfort, due to the currently wearing shoes, while working in the summer. Both males and females showed more than 3.9 points in such items related with pleasantness of feet as "feet feel hot while working on a hot day", and "feet easily get damp" (Table 3). That is, males and females showed severe discomfort, and the reason is that both males and females wore many boots made of non-air permeable materials. According to a study that compared thermal burden by shoes type (Lee and Choi, 1996a), moisture generated from skin is hardly evaporated, and remained within boots, which raised humidity within the boots, and induced discomfort to those who wore boots, when working wearing the boots. Because, heat radiation from boots with wider area covering foot and lower limb was not effectively carried out, compared to sports shoes or rubber shoes, the boots gave the highest thermal burden to workers.

In such an item as "foreign substances like soil and sand go inside the shoes well", females felt more discomfort than males. The reason was that females wore mainly low height shoes such as ankle height boots, sports shoes or new rubber shoes, and these shoes had wide ankle opening for convenience of wearing and taking off, and therefore, there were lots of inflows of foreign substances.

Table 3. Discomfort level of the shoes currently worn

Item	Male	Female	Total	t-value
Uncomfortable experience because of the shoes while working in the summer	3.7±0.8	3.8±1.1	3.7±0.9	3.305
Feet feel hot in working on a hot day	3.9±0.9	3.8±1.1	3.9±0.9	5.932**

Table 3. Discomfort level of the shoes currently worn (Continued)

Item	Male	Female	Total	t-value
Feet hurt since the shoes do not fit.	2.8±0.9	2.6±1.1	2.7±1.0	3.337
Hard bottom of the shoes feels uncomfortable	3.1±1.0	2.9±1.2	3.0±1.1	2.386
The shoes are heavy	3.3±1.0	2.9±1.1	3.1±1.1	0.210
It is difficult to put on and take off the shoes	3.5±1.0	3.2±1.3	3.4±1.1	5.130*
Feet easily get damp.	4.0±1.0	3.8±1.1	3.9±1.0	0.635
There is a less inflow of foreign substances like soil and sand	3.7±0.9	3.9±1.2	3.8±1.0	6.452**
The shoes are easily taken off	2.7±1.0	2.5±1.1	2.6±1.0	0.182
The bottom of the shoes is slippery	3.2±1.0	3.0±1.1	3.1±1.0	1.260
The shoes are poorly waterproof	3.0±1.1	2.8±1.1	3.0±1.1	0.256

M ± SD, * $p < .05$, ** $p < .01$

3.2 New design according to agricultural work

Based on preceding studies and questionnaire survey results, this study designed summer agricultural work shoes, according to main items in designing agricultural work shoes. Figure 2 shows designed agricultural work shoes. Shoes can be divided into the upper part covering the top part of a foot, and the sole part of which a foot contacts the surface of the earth. The sole can be divided into outsole, midsole and insole, more specifically.

**Figure 2.** Prototype of agricultural work shoes for summer

- Pattern design

In a study of Kim et al. (2012), it was known that farmers' foot types and shapes had differences from those of general public, and

that farmers had higher top of the foot and wider foot than the general public. Using analysis results of morphological features of farmers' feet, this study made foot list, applied it, and designed pattern. The agricultural work shoes developed in this study were designed with margin on the whole, and are considered to improve the feeling of wearing, and contribute to the foot fatigue reduction even in the long-time wearing.

- Upper part design

First, farmers work on uneven ground and work walking up and down ridge between fields, and therefore, ankle bending can be easily caused. In this regard, this study designed the height of upper part to be six inches, higher in ankle part than existing many-worn sports shoes, so that workers' ankle bending can be safely protected.

This also can prevent the inflow of foreign substances, since the shoes's neck is higher and entrance is narrower than sports shoes, and thus the shoes can prevent the inflow of foreign substances.

Second, the upper part of shoes is based on polyurethane (PU) family synthetic leather from a material aspect, and cordura is used partially so as to give air permeability. PU is more expensive than PVC, but PU is an eco-friendly product, and offers more excellent water vapor permeability and the feeling of touch, and is widely used as the material for upper part of sports shoes and hiking shoes recently. Cordura used to provide air permeability was originally developed for military use. Cordura is light, and has high wear resistance and tensile strength, and therefore, it is widely used for military personnel's combat uniform, combat shoes and outdoor supplies. Cordura fabric's air permeability is slightly lower than that of mesh fabric. However, the cordura with good durability can safely protect the foot from sticking plants or being caught by plants. Due to outstanding basic living water proof function and pollution prevention function, cordura is considered to be more appropriate for the material of agricultural work shoes than mesh.

- Sole design

First, the design of outsole, which is the most outer layer among soles in the case of agricultural work shoes, is also very important. Korea's rural area earth mainly consists of soil, sand and remains of decayed plants. Actually, rain or dews generated during the whole night meet earth, and thus small puddles are formed, or water permeates into soil, and mud is made. Because of this, overturn accidents like slipping frequently occur. As shown in the questionnaire questions, 24.8% of the survey respondents (2nd most) answered to the question why they chose agricultural work shoes as follows: foreign substances are not caught well between the grooves of outsole. Also, 3.8 ± 1.0 was also revealed in the question of discomfort. In addition, the respondents



Figure 3. Shape of the outsole

answered with 3.1 ± 1.0 to the question from the current shoes' slipping aspect. In this regard, this study designed the shoes' pattern of outsole big, and groove to be deep as shown in Figure 3.

Second, this study applied insole reflecting farmer's foot shape so that foot pressure can be evenly distributed even in the case of wearing the shoes for a long time. This will evenly distribute foot pressure, and enable stable walking. By applying the top-cap made of high density PU 1.4 material to the front part of the work shoes, farmer's toes can be protected from rocks or pebbles. Concerning industrial safety shoes, the area of top-cap is distributed wide, which can be a cause of adding the weight of shoes. However, the top-cap's area of the shoes developed in this study was made slightly smaller than existing safety shoes, and therefore, safety, light weightiness and air permeability were considered together.

Rural area is inferior to urban area in terms of street lights, and pedestrian identification is more difficult in rural area than urban area for night time driving. For this reason, night time pedestrian car accidents frequently occur (Park, 2014). During the summer, when heat wave increases each year, lots of agricultural work are done at dawn or at night to avoid the heat of the day. To reflect such a situation, retro-reflectors were applied to the heel part and sides of the shoes in this study, and therefore, farmer's safety was ensured, and aesthetics was offered as a design factor (Figure 4). Eco-friendly khaki was selected as the color of the retro-reflectors so that pollution is not easily detected, even after pollution with dust, and red retro-reflective decoration was added.



Figure 4. Retro-reflectors function

4. Conclusion

This study aims to develop the design of functional agricultural work shoes for summer suitable for the agricultural environment and work characteristics as a type of personal protective gear for farmers. The work shoes actually can help their healthy life and safe work, and enhance work efficiency. To this end, this study targeted 174 farmers, and examined the problems and improvements of the work shoes that they currently wear through wearing reality survey. With all this, this study identified the requirements of agricultural work shoes, and designed the shoes.

As a result of surveying the wearing reality and discomfort of the current work shoes in the summer agricultural work, males and females showed difference in the height of the shoes, and both males and females wore boots most, followed by sports shoes,

due to convenience and economic efficiency. However, they experienced discomfort, owing to shoes, in the case of working in the summer wearing such shoes, and especially, they showed very low satisfaction from a pleasantness aspect such as feet feeling hot or feet getting damp.

This study drew the requirements of agricultural work shoes and designed agricultural work shoes for summer, based on the questionnaire survey and preceding studies. The designed shoes' characteristics are as follows: In view of agricultural work characteristics, in which farmers work on the steep paths a lot, this study set the ankle part of the shoes to six inches in order to prevent the bending of ankle and inflow of foreign substances. When the outsole's pattern is smaller in size, soil and sand are caught, which may cause slipping by reducing friction force with ground. For this reason, this study prevented foreign substances' being caught by making the pattern and groove bigger. Proper combination of PU synthetic leather and cordura was used for the upper part, and air permeability that was pointed out as a discomfort of existing work shoes was tried to be ensured. Such materials are considered to offer satisfaction to the shoes users by offering outstanding feeling of touch and pleasantness. This study also designed agricultural work shoes to fully exert functions as safety shoes by applying high density PU material top-cap in order to protect toes from rocks or pebbles. Also, this study applied retro-reflectors around the heel part, sides and string of the shoes to ensure aesthetics and safety of workers at night time walking. For overall color, khaki was selected for convenient management from pollution, and the different string color was used for distinction.

This study has limitation in that wearing and performance evaluation was not conducted, after the design development. However, this study expects that studies on personal protective gear development, which can reduce farmers' work burden and keep their safety at agricultural worksites, are continuously carried out, and head towards better direction. In a further study, the efficiency of the developed actual agricultural work shoes needs to be verified, after actual shoes are manufactured on the basis of design, and evaluation on satisfaction with wearing and safety targeting farmers is conducted.

Acknowledgements

This study was carried out with the support of "Research Program for Agricultural Science & Technology Development (Project No. PJ008420)", National Academy of Agricultural Science, Rural Development Administration, Republic of Korea.

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