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Analysis of Work Time in Agriculture Through Time-Diary Method and Evaluation of the Reliability of the Data Using GPS Device

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Objective: In this paper, work time for the representative fruit crops are collected and analyzed using time-diary method, and the collected data were compared with the directly observed work time using GPS device.

Background: There is no consistent conclusion which measurement method for work time is accurate. Most of the research results were collected from the environment other than rural area. Therefore, there is need to review reliability of the measurement methods for the agricultural work which are carried out for a long duration.

Method: Top five crops (apple, pear, grape, sweet persimmon, and peach) were selected according to the number of farms and cultivation areas. We let fruit growers fill a work diary during one cropping period. A difference between the work-time that was recorded by the farmers and the direct observed worktime using GPS device were analyzed.

Results: Average direct work time for the five fruit crops found to be 7.1% of the total work time.

Conclusions and Applications: Reliability was secured by recording the daily work diary at each work stage while aware that direct observation is carried on. Data which are being collected by government institutions are obtained by the memories of the respondents. Therefore, it is needed to try the method adopted by this study in order to collect more accurate data.

Keywords: Agriculture, Work time, Time-diary method, GPS

1. Introduction

Farmers in Korea are facing a difficult situation of increasing longer work time and work intensity due to shortage of workforce by aging and empty of rural community. Besides, though dependency on the farming equipment and pesticides are increasing, and they are seriously exposed to musculoskeletal disorders, a compensation related with the accidents and disasters is meager. Work Compensation Insurance limits the scope of the beneficiary as corporate or workers in the workplace having more than five workers, it is not applicable to the small-scale self- employed farmers who are common in the rural area in Korea. Further, safety insurance products under sale by

the private insurance companies have a weak legal base, and provide a low compensation as compared with the Work Compensation insurance. Therefore, efforts to arrange for farmers to engage in farming stably by providing a proper compensation for the safety related incidents during farming work have been pursued by government and political circles (Ministry of Agriculture, Food and Rural Affairs, 2016).

In order to establish compensation standard for the safety incidents for the farmers, compensation amount for the substitute labor has to be decided. For that, work time at each work stage per crop has to be investigated. Worktime per work stage and per crop is investigated on a yearly basis through 'Income status data for agricultural and stockbreeding products', the Rural Development Administration of Korea. However, this survey is conducted with the direct recording method (40~50% of the survey subjects) using work diary and recording with a help of recollect by farmer when local extension worker visits (four times/year) (50~60%), there is a limit in analyzing from where error in the work time is generated.

Generally, several methods are used to measure work time (Ploeg et al., 2000) representative ones are time diary method, experimental sampling method, and self-reported questionnaire. In the time diary method, there are two categories; oneis to provide exact time, while another is not providing the exact work time. In the method wherein time is provided, respondent records directly in the diary where the uniformly divided time scale in 24 hours a day with his narration just like a writing a diary in the survey sheet for time usage. Whereas, in the method where time is not provided, respondent records the starting-time and end-time from one activity to another activity with detail of the activities done during that period. Experimental sampling is a method which respondent records his activity whenever programmed signal is randomly ringing from the beeper, and is a similar concept with the work sampling in time and motion study. Self-reported questionnaire is a form on which respondent writes worktime for the last week by judging subjectively. Question modes are, for example, "please, write the worktime during which actual works were executed by day", or "how many hours were spent for average over work time in a week" etc. These are measurement methods for the paid work time which is officially published by the Statistics Korea. Questionnaire method is widely being used when time usage along with various consciousness or attitude (e.g., degree of feeling time-bound stress or sense of values for a specific subject etc.) are investigated.

There is no consistent conclusion which method is accurate among the various work time measurement methods (Prince et al., 2008; Koning et al., 2010). Besides, most of the results from these research was collected from the environment other than rural area, which needs to review reliability of the measurement methods for the agricultural work involving long-time work. Therefore, in this study, work times for the representative fruit crops were collected and analyzed by using time diary. These analysis data were compared with work times which were directly observed using GPS devices. The results of this study could be utilized to set the standard for compensation as substitute labor when damage and disaster are occurred along with for providing methodology for work time measurement by crops and by work steps.

2. Methods

2.1 Selection of the crops

Top five crops (apple, pear, grape, sweet persimmon, and peach) were selected according to number of farms and cultivation areas by referring to the results published by the Agriculture and Fisheries Census which is being conducted for every five years (Statistics Korea, 2015). The crop apple occupied the largest both in the number of farms and cultivation areas, while number of farms devoted for pears were less, yet the average cultivation area per farm was the second largest (Table 1).

Table 1. Acreage of fruit crops

Crop	No. of farms	Acreage (ha)	Acreage/farm (ha)
Apple	38,765	32,789	0.85
Pear	22,589	16,110	0.71
Grape	31,223	14,457	0.46
Persimmon	28,443	11,365	0.40
Peach	26,385	13,381	0.51

2.2 Data collection

As can be seen in Table 2, preparation of the work diary was requested for one cropping period subjected to the five crops and a total of 40 farms (average age of the subjected farmers: 58.3). In the work time, work stage, work place, and time for direct works and indirect works (e.g. sales, maintenance and repairing the facilities and machines, and items purchase etc.). We periodically called and sent messages to the farmers for confirming preparation of the work diary, and also we checked if work diary was properly recorded by getting cooperation of local Agricultural Technology Center.

Table 2. Diary keeping practices

Crop	No. of farms	Period (2015)
Apple	8	March ~ October
Pear	5	September ~ October
Grape	9	April ~ October
Persimmon	10	May ~ October
Peach	8	March ~ October
Total	40	

2.3 Reliability evaluation for the work diary data

Difference was analyzed between work times which were directly recorded by the farmers from 40 farms for 53 rounds (13 rounds for apples, 10 rounds for peaches, 5 rounds for pears, 13 rounds for grapes, and 12 rounds for sweet persimmons) and work time directly observed by using GPS device (ASCEN PS850) which is shown in Figure 1 (92 work steps, average work observation time: 137 min.). For that, work traffic line during farmer's working was checked by using trajectory of the GPS device.

The movement route inside orchard appears as in Figure 2. When work traffic lines are analyzed with analysis program in the GPS device, work time as per work place can be extracted.

Figure 1. GPS device

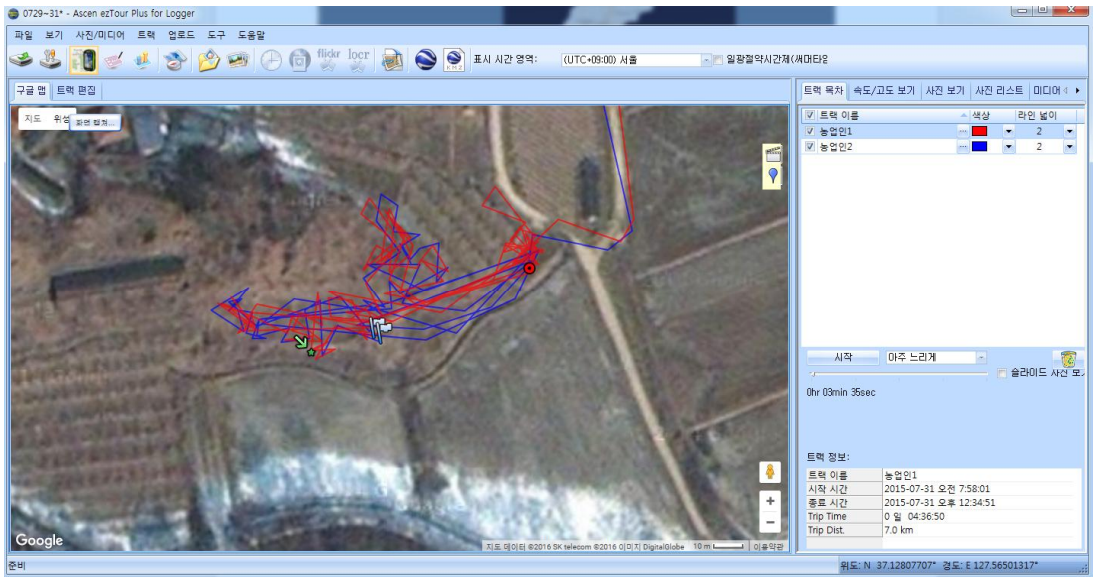

Figure 2. Example of trajectory

3. Results

3.1 Analysis of work time

Work time which was recorded in the diary is arranged according to the major work stage as in Table 3 and Table 4. Time for harvest for peaches and pears occupied 34.2% and 43.6%, respectively among the total work time, while weeding work for apples, grapes, and sweet persimmons occupied more than 20%.

The weight of indirect work time by crop showed that (Table 4) pears were the highest with 14.6% followed by peaches at 8.5%, grapes at 7.5%, apples at 4.7%, and sweet persimmons at 3.5%. Indirect work-time for five fruit crops was 7.1% among the total.

As shown in Table 5, higher indirect work for the grapes was due to higher processing work as compared with other fruit crops. In the indirect work, sales were included. In apples, peaches, and pears, time related with orchard management/maintenance was the highest, followed by shipping related works, work preparation (packing and harvest), maintenance and repair of the facilities and machines, and agricultural items purchase (pesticides and package related items).

Table 3. Time for major steps (h/10a/year)

Crop	Time (%)					
	Total (h)	Harvesting	Disinfection	Cutting off sprouts	Weeding	Others
Apple	87.39	8.20 (9.4)	6.93 (7.9)	11.79 (13.5)	20.40 (23.3)	40.07 (45.9)
Pear	26.66	11.63 (43.6)	5.36 (20.1)	0.00 (0.0)	1.03 (3.9)	8.64 (32.4)
Grape	111.55	18.54 (16.6)	5.22 (4.7)	21.45 (19.2)	27.19 (24.4)	39.15 (35.1)
Persimmon	29.38	8.19 (27.9)	4.88 (16.6)	3.72 (12.7)	8.58 (29.2)	4.01 (13.7)
Peach	50.46	17.28 (34.2)	4.49 (8.9)	3.37 (6.7)	7.57 (15.0)	17.75 (35.2)
Average	61.09	12.77 (20.9)	5.37 (8.8)	8.07 (13.2)	12.95 (21.2)	21.93 (35.9)

Table 4. Direct/indirect time

Crop	Total time (h/10a/year)	Direct time (%)	Indirect time (%)
Apple	87.39	83.28 (95.3)	4.11 (4.7)
Pear	26.66	22.76 (85.4)	3.90 (14.6)
Grape	111.55	103.21 (92.5)	8.34 (7.5)
Persimmons	29.38	28.36 (96.5)	1.02 (3.5)
Peach	50.46	46.16 (91.5)	4.30 (8.5)
Average	61.09	56.75 (92.9)	4.32 (7.1)

Table 5. Indirect time (h/10a/year)

Crop	Time (%)					
	Education	Facility and equipment repair	Purchases	Preparation	Shipment	Processing
Apple	0.5 (12.2)	0.9 (22.0)	0.4 (9.8)	0.9 (22.0)	1.4 (34.1)	–
Pear	–	–		0.4 (10.3)	1.2 (30.8)	2.3 (59.0)
Grape	0.7 (8.4)	2.3 (27.7)	0.8 (9.6)	1.2 (14.5)	3.3 (39.8)	–
Persimmon	0.2 (20.0)	0.3 (30.0)	0.2 (20.0)	–	0.3 (30.0)	–
Peach	0.3 (7.0)	0.5 (11.6)	0.6 (14.0)	0.4 (9.3)	1.1 (25.6)	1.4 (32.6)
Average	0.4 (9.9)	1.0 (23.3)	0.5 (11.6)	0.7 (16.9)	1.5 (34.0)	1.9 (43.0)

Process related work-time was the largest in the pears, while harvest related work-times were the highest in apples, pears, grapes, and peaches. Generally, processing took the highest work-time, followed by outgoing, maintenance and repair of facility/equipment.

3.2 Evaluation of reliability for daily diary using GPS

Analysis results showed that the work time recorded in the diary was higher on an average by 7% than the time measured by GPS, but not with significant difference [$t(52)=0.628$]. It might be because error by recollection became minimized by preparing daily diary just after completion of the work stage. Further, with GPS device attached, farmer aware that his work is monitored, so that accuracy was maintained. However, if general diary preparation mode was followed (recording at once in the evening or after some days), the result might have been different.

4. Conclusion

In this study, work times for five major fruit crops were collected and analyzed using time diary, and the results were compared with the direct observation times monitored by GPS device. The results showed that reliability of the work time was secured by preparing diary for each work stage while farmers aware of being observed.

Time diary method, experimental sampling method, and questionnaire method, though have limits, these are recommended as recording methods for work time (Jacobs, 1998). It has been reported that with daily diary method, time was tended to be overestimated as compared with the questionnaire method (Koning et al., 2010), and accuracy was more or less low as compared with the direct observation (Prince et al., 2008). Further, Robinson and Godbey (1997), in the population census, time given to the respondents to respond was only a fraction of second, therefore, respondents would hurriedly recollect the event and responded. Besides, a person who works a long time exaggerate his work time. If continuous observation equipment like GPS which is adopted in this study is used, reliability for measurement and data collection would be raised.

Data collected by most of the national organizations including the Statistics Korea are being collected by the recollection of the respondents. However, for more correct data collection, the method adopted in this study could be tried.

This study has a limit of not estimating a test-retest reliability. However, the reason could be an inherent nature of agricultural work which the same work is not exactly repeated with time gap.

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