Impact of allowance time in manual harvesting of pomegranate: application of stop watch time study technique

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Abstract: Human power is the main resource in all production units like agriculture. Suitable working condition is essential to enhance job satisfaction and productivity of human resources. Stop watch time study was used in this study for the first time in Iran's horticulture sector in order to give correct estimation of laborers' productivity for pomegranate harvesting while mechanized harvester machines are limited. The pomegranate harvesting process was broken into its seven elements. The require time for doing each element was recorded and necessary allowances for each element was obtained from time study standards tables. Ten out of 37 gardens were randomly chosen and the works of three laborers from each garden were observed and recorded with three replications. Level of job satisfaction was investigated using Job Descriptive Index (JDI) questionnaire to understand whether employing suitable number of laborers enhances job satisfaction. The results showed that two groups of laborers harvested pomegranate with different speeds, the middle-aged laborers (36-55 years old) required more allowances than the young laborers (20-35 years old) of laborers. Statistical analysis revealed high correlation between frequencies of picking pomegranate task and observed time by 92% (inverse relation) meaning that the sample laborers worked highly similar. The average productivity of young and middle-aged groups of laborers were harvesting 37 kg h^{-1} and 29 kg h^{-1} pomegranate, respectively. Accordingly, it was determined that six laborers are needed from the young group or eight laborers from the middle-aged group to harvest 22,000 kg ha^{-1} pomegranate in a working time of 12 days (8 h day^{-1}). Using a suitable number of laborers in any work would lead to reaching actual laborers' productivity and on time work accomplishment besides high level of job satisfaction. The proposed methodology can be applied in other sectors/organizations with further investigation into enhancement of health and safety of laborers in different working conditions.

Key words: Allowance, work study, job satisfaction, safety

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1 Introduction

Human resources are the most important agricultural capital. Any increase in the productivity of human resources will enhance the total productivity (Otsuka, 2007). Productivity includes some concepts such as production, income, yield and costs (Lien et al., 2017). Correct management of human resources play an essential role in productivity development (O'Donnell et al., 2017). Since there are few mechanization machines for harvesting fruit tree yield in Iran, harvesting is largely depending on the human laborer resources. The limitation in human laborers during the short time period of pomegranate (12 days) harvesting suffer the gardeners.

The most essential factor affecting harvesting productivity is the lack of information to show how many laborers should be employed to harvest a garden. Thus, the laborers maybe dissatisfied with the working conditions when they believe that their numbers should

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be more to reduce working pressures. Secondly, when there are not suitable number of laborers to harvest pomegranate, some timeliness costs may impose to gardeners. Thirdly, the gardeners may have to pay more wage to laborers when scientific information is not available to show how many laborers should be employed to harvest a garden. A large portion of farming costs may be the payments to laborers in some labor-intensive tasks such as harvesting fruits. Having a correct estimation of required number of laborers to harvest fruit on time is essential to reduce harvesting costs. In addition, the pressure on the laborers will be diminished when enough number of laborers are available to harvest a garden (Almasi et al., 2002).

Every task in pomegranate harvesting should be analyzed carefully to reach a correct estimation of required laborers to do the tasks. There are three methods to measure work magnitude: activity sampling, work study and time study. Time study was used in the current study. Time study is a tried and tested method of work measurement for estimating basic times and standard times for carrying out a specified work. Time study was established in 1881 by Taylor (Russell and Taylor, 2005). They found that the main obstacle between managers and laborers is that the manager has no actual idea about the volume of daily works that should be completed by the laborers. Taylor separated a task to its elements one by one to understand how a task can be completed in a given time. In other words, the aim of the time study is to establish a time for a qualified worker to perform specified work under stated conditions and at a defined rate of working speed. Although work study and time study are the useful tools to increase productivity, they are not applied widely in practical fields (Bon and Daim, 2010). Amitabha and Rabindranath (1992) have investigated that the speed of farm laborers in rice production work is 1.39 m s^{-1} and they work faster than usual speed. Duran et al. (2015) have increased laborers' productivity by 53% in a glass production firm by reducing waiting times which was estimated by time study technique. A work study in a manufacturing unit in India has reported that productivity can be enhanced via simplifying and rearrange the sequence of operations to make the job easier (Chandra, 2013).

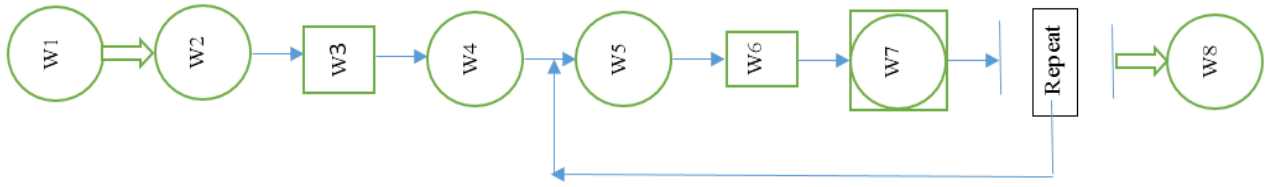
When the laborers are satisfied with their jobs, it can be expected that most productivity is obtained. Job satisfaction is one of the most researched variables in the area of workplace psychology and represents that how people like their jobs (Fritzsche and Parrish, 2005). Although age and income are important factors affecting job satisfaction (Troesch and Bauer, 2017), working with higher than usual speed would lead to chronic fatigue and reduce job satisfaction. Thus, employing suitable number of laborers or clerks in different works may reduce work-related pressures and stresses and enhance job satisfaction. In turn, the human resources productivity would be increased when individuals are satisfied with their jobs.

Currently, most pomegranate gardens are harvested using laborers in Iran since mechanized harvesters are not sufficiently provided for the gardeners. Thus, it is essential to have a right estimation of the required laborers to harvest a garden to benefit both laborers and gardeners. Accordingly, the objective of this study was to evaluate the conventional pomegranate harvesting tasks by application of time study technique and to estimate the suitable number of laborers to harvest a pomegranate garden with regard to a given yield in a given harvesting time. This study argues that laborers' job satisfaction will be increased when the necessary allowances are applied in the pomegranate harvesting working conditions. Accordingly, the level of job satisfaction was evaluated by job descriptive index (JDI) questionnaire before and after application of time study technique to investigate how availability of required number of laborers in a work can improve the level of job satisfaction.

2 Materials and methods

This study was conducted in Fall 2017 in Fars province, Southwest Iran. The data was collected from 10 gardens out of 37 gardens randomly, and six laborers were studied from each garden. Almost all the working laborers in each garden were imported to the study without statistical sampling. The working hours were 8-

12 A.M. and 14-18 P.M. (8 h day^{-1}) in November. Regarding different ages, the laborers were put into two groups, i.e. 20-35 years old and 36-55 years old. The two groups were considered as independent groups and statistically analyzed using one-way ANOVA test.



1: bringing an empty box to the garden; 2: putting the box near a pomegranate tree; 3: primary inspecting of the tree; 4: putting the box in a suitable place near the tree in order to harvesting pomegranate; 5: picking pomegranates; 6: inspecting pomegranate; 7: putting pomegranate in the box; 8: putting the filled box out of the garden

Figure 1 Activities of pomegranate harvesting

2.1 Stop watch time study

A complete job usually is too long and would be analyzed into several smaller parts (elements) which can be separately timed and rated (Hedman et al., 2013). Stop watch time study method was applied in this study. In order to use this method, firstly, the pomegranate harvesting activity was broken into small task elements. The operation flowchart model of pomegranate harvesting (as drawn in Figure 1) includes: 1- bringing an empty box to the garden; 2- putting the box near a pomegranate tree; 3- primary inspecting of the tree; 4- putting the box in a suitable place near the tree in order to harvesting pomegranate; 5- picking pomegranates; 6- inspecting pomegranate; 7- putting pomegranate in the box; 8- putting the filled box out of the garden. The model given in Figure 1 clarifies that pomegranate harvesting starts with bringing an empty box to the garden and ended with putting the filled box out of the garden. The Pomegranate harvesting activities timed four times, i.e. 1- 8-9 A.M. (first hour of working at morning), 2- 11-12 A.M. (last hour of working at morning), 3- 14-15 P.M. (first hour of working at afternoon) and 4- 17-18 P.M. (last hour of working at afternoon). The time required for doing all the task components during working of each laborer was calculated with three repetitions by a digital chronometer. This recorded time is known as "observed time" (Esmaaeili, 2008).

The "normal time" is the time required to perform the work activity at a normal speed, under normal working conditions and using a prescribed method. A normal speed means that working can be consistently performed by an average laborer without undue fatigue. It is obvious that individuals may not work at a similar speed or people may speed up their efforts when they are being observed. Accordingly, the "observed time" which is recorded from time study of each work task should be adjusted by a performance factor embedding the workers' effort. Then, "normal time" is (Aliahmadi, 2014):

$$\text{Normal time} = \text{Observed time (OT)} \times \text{Performance rating factor (PRF)} \quad (1)$$

Performance rating factor (PRF) is a judgment by the person who timed the tasks. Usually, PRF is the average of several replications to show the actual laborers' PRF. PRF can be equal to 100% (working at a normal speed), below 100% (working below normal speed) or above 100% (working above normal speed). "Normal time" lacks the required time for personal needs or unavoidable delays. In other words, a laborer cannot work for long time under normal speed. "Allowances" include some time to compensate laborer's fatigue, personal needs and rest periods. "Standard time" shows a task can be done at normal pace for long time and calculated as followings:

$$\text{Standard time} = \text{Normal time}\ (1 + \text{allowance factor}) \quad (2)$$

2.2 Determination of allowances

Extra allowances should be estimated for the laborer’s fatigue recovery and personal needs such as toilet break and equipment breakdowns (Aliahmadi, 2014). The allowance is an addition to the basic time

intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. To determine a number of necessary rest allowances for each task, delay or fatigue scores were extracted from work-study standard tables (Aliahmadi, 2014). There are several tables assigning scores for work conditions based on physical pressures, required mental focuses on a given task, temperature, light intensity, dust, sound, etc. Under difficult conditions, however, a laborer may need a higher level of allowance. For example, a laborer with a disability or wearing glasses may need extra allowances. The percentage of allowance is then determined by the estimated scores. As shown in Table 1, for an average physical attempt (e.g. carrying a 12 kg box), fatigue score is 17 and respective percentage of allowance is 11% (Aliahmadi, 2014). After estimation of actual time necessary for pomegranate harvesting while all the limitations and allowances were considered, the required number of laborers for harvesting one hectare pomegranate garden can be precisely estimated.

Table 1 Factors of laborer fatigue and their appropriate allowances

Factor	Sub-factor	Score	Percentage of allowances
Physical tasks	Light (5 kg)	11	1%
	Medium (12 kg)	17	12%
	Heavy (25 kg)	39	18%
Pressure on eyes	Usual tasks with good light	1	0%
	Distinction of one object from others	2	10%

When standard time for doing pomegranate harvesting task was determined, the actual productivity could be calculated. Productivity is simply defined as 'the ratio of output to a given input'. Actual productivity of a laborer was determined as kg harvested pomegranate in one standard hour (kg h^{-1}), i.e. when allowances were considered.

2.3 Job satisfaction analysis

JDI questionnaire developed by Smith et al. (1969) was used to determine how laborers in pomegranate harvesting task are satisfied with their job. Validity and reliability of JDI questionnaire in Iranian society was previously investigated in a study by Noorbakhsh and Alizadeh (2006). They stated that the reliability and validity of the questionnaire are 0.92 and 0.86, respectively. Answering to JDI questionnaire is simple and high level of education is not necessary (Michelle et al., 2009). The questionnaire contains 72 close-ended questions. The total score on the JDI is supposing to measure total job satisfaction ranging from 30 to 150 while 30-54 is "very dissatisfied", 54-78 is "dissatisfied", 78-102 is "moderate satisfaction", 102-126 is "satisfied" and 126-150 is "very satisfied" (Ayan and Kocacik, 2010).

The JDI score was determined both before and after applying time study technique to find that whether reduction of working pressures and using suitable number of laborers leads to higher job satisfaction. The level of job satisfaction can be affected by many factors including environmental, e.g. fairness in the workplace, and ergonomics and personal factors, e.g. gender, age, and social differences (Vakola and Nikolaou, 2012). The level of job satisfaction evaluated for two groups of laborers separately.

3 Results and discussion

3.1 Analysis of pomegranate harvesting activity

Tables 2 shows the time required for completing each task of pomegranate harvesting. The data of OT revealed that both the groups of laborers, i.e. 20-35 years old and 36-55 years old required similar percentage of time for accomplishing a task. For instance, both groups required highest time for doing task *W5* (Picking pomegranates) and lowest time for doing tasks *W3* (Primary inspecting of the tree) and *W4* (Putting the box in a suitable place near the tree in order to harvesting pomegranate). Yet, the allowances are not embedded in OT which means that if a gardener ask laborers to harvest pomegranate according to OT, there will be some pressure on the laborers which may lead them to fatigue and dissatisfaction. The amount of NT×Frequency for task *W5* (for young group) shows

that 117 times Picking pomegranates should be completed in 12.74 (~ 13 min). But, when allowance was considered, 117 times Picking pomegranates should be completed in 15.73 (~ 16 min). Figure 2 shows the required allowances for each task of pomegranate harvesting revealing that the laborer group of 36-55 years needs higher rates of allowances in comparison to the young group (20-35 years).

The PRFs were different for tasks and laborers. In average, the task *W1* and *W2* had the highest PRFs, whereas, tasks *W5*, *W7* and *W8* had the lowest PRFs. Most the tasks had PRFs below 1 meaning that the tasks are accomplished below normal speed. PRF of tasks *W1* and *W2* show that both tasks are done above normal speeds in both groups of laborers. PRF of middle-aged laborers were lower than young laborers in all tasks. Although the frequency of tasks in one hour were similar for some tasks, there were very difference between the groups in doing some tasks such as *W5*. The young group repeated this task of around 117 times per hour while it was around 90 times per hour for the middle-aged group. Thus, a primary investigation indicates that the working speed of the middle-aged laborers are totally different from the young laborers. In other words, the gardeners should keep it in mind that they would need more time to harvest a garden if they have a group of middle-aged laborers. The statistical analyses revealed significant differences between two groups of laborers for doing tasks *W5*, *W6* and *W7*. In addition, the observed times for doing tasks *W5* and *W6* were significantly different between the two groups of laborers. The frequencies and observed times of other tasks were similar between the groups of laborers without statistical differences.

Table 2 Time study of pomegranate harvesting

Group of laborers	Harvesting task elements	Frequency (in 40 min)	Observed time (OT) min	Performance rating factor (PRF)	Normal time (NT) min	NT×Frequency (min)	Allowances %	Standard time (min)
20-35 years	*W1*	1	3.56	1.2	4.27	4.27	15.30	4.92
	W2	3.2	0.19	1.12	0.21	0.68	12.40	0.77
	W3	4.4	0.11	0.95	0.10	0.43	12.30	0.48
	W4	3.5	0.14	0.95	0.13	0.45	16.50	0.52
	W5	117.6	0.12	0.9	0.11	12.74	23.50	15.73
	W6	117.6	0.06	1	0.06	7.25	14.20	8.28
	W7	108.5	0.06	0.9	0.05	5.61	15.70	6.49
	W8	1	10.83	0.9	9.75	9.75	49.50	14.58
	Sum	--	--	--	--	41.18	--	51.77
36-55 years	*W1*	1	4.47	1	4.47	4.47	15.20	5.15
	W2	3.6	0.22	1	0.22	0.80	12.50	0.90
	W3	5.2	0.13	0.9	0.12	0.60	12.40	0.67
	W4	3.5	0.14	0.9	0.13	0.46	16.50	0.54
	W5	90.5	0.16	0.85	0.14	12.97	26.50	16.41
	W6	90.5	0.07	0.95	0.07	6.49	14.30	7.41
	W7	83.7	0.06	0.85	0.05	4.32	19.60	5.17
	W8	1	12.07	0.85	10.26	10.26	54.50	15.85
	Sum	--	--	--	--	40.37	--	52.10

Note: *W1:* Bringing an empty box to the garden; *W2:* Putting the box near a pomegranate tree; *W3:* Primary inspecting of the tree; *W4:* Putting the box in a suitable place near the tree in order to harvesting pomegranate; *W5:* Picking pomegranates; *W6:* Inspecting pomegranate; *W7:* Putting pomegranate in the box; *W8:* Putting the filled box out of the garden.

As described in Materials and Methods, the time required to complete pomegranate harvesting activities recorded four times, *i.e.* 1- 8-9 A.M. (first hour of working at morning), 2- 11-12 A.M. (last hour of working at morning), 3- 14-15 P.M. (first hour of working at afternoon) and 4- 17-18 P.M. (last hour of working at afternoon). No significant variation was found on the frequency of tasks except for tasks *W5* and *W6*. At the beginnings of the work, *i.e.* 8 A.M. and 14 P.M., the frequencies of these two tasks reached to 130 and 105 for young and middle-aged groups, respectively which showed higher productivity of laborers at these hours. The data in Table 2 is the average values of recorded times at the first and last hours of working (morning and afternoon). Thus, it can be expected that a laborer may continuously works with this speed during hours a day.

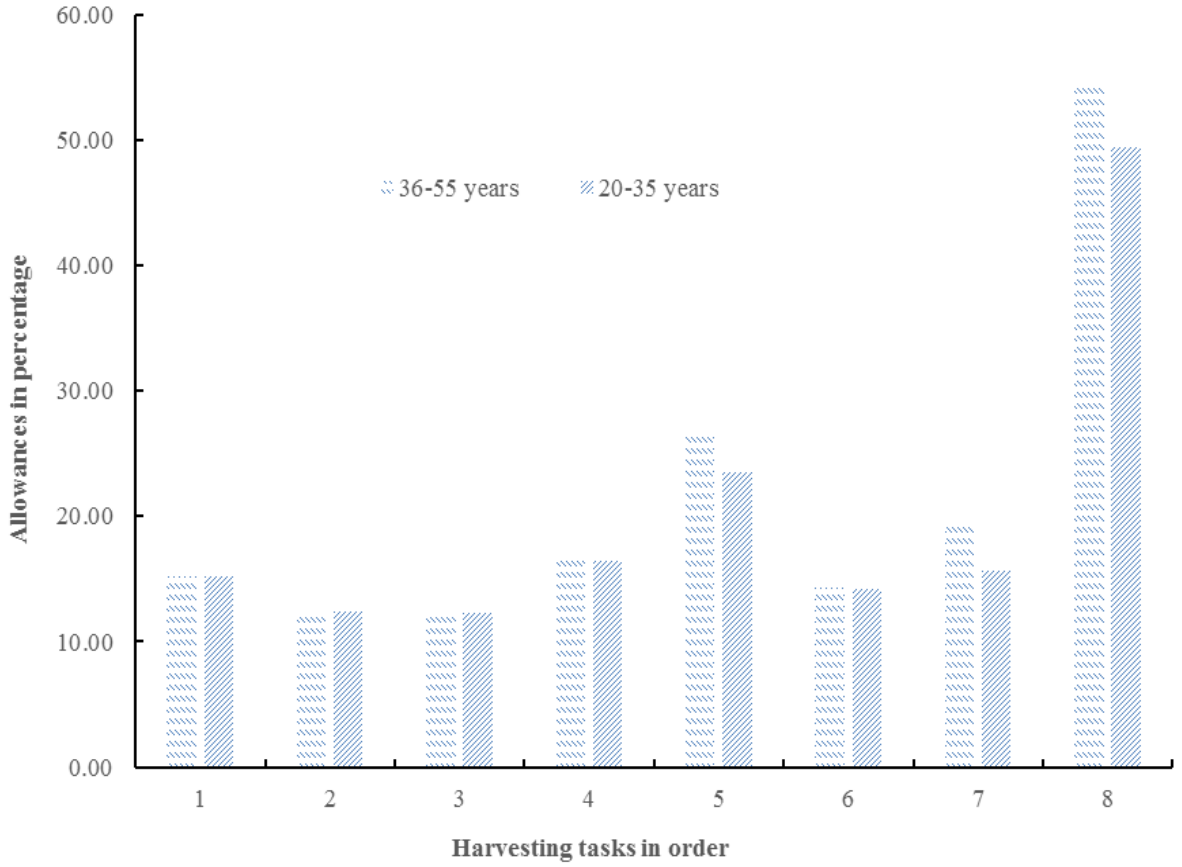


Figure 2 Percentage of allowances in pomegranate harvesting

3.2 Statistical analysis

The correlation analysis revealed a high correlation of 92% between the frequency of the task *W5* and the observed time of this task. Figure 3 shows the high and inverse correlation between these variables. Since the data were related to the 30 laborers in group 20-35 years, the high correlation reveal that all the sample laborers worked with suitable speeds especially for the task *W5* (picking pomegranates). In other words, all the laborers worked with similar speeds and there were not some very high-speed or very low-speed workers. Similar results were found for middle-aged group of laborers (36-55 years) with the correlation of 94% between the frequency of the task *W5* and observed time of this task. High similarity amongst the sample laborers is useful. Because when normal time and standard time are estimated based on the average data gathered from 30 laborers, the estimated values can be expected from each laborer. Thus, it is expected that each laborer works according to estimated values without unavoidable fatigue or job dissatisfaction.

3.3 Estimation of productivity and required number of laborers to harvest pomegranate

The field observations revealed that the pomegranate should be harvested in 12 days (8 h day-1) to transfer to the market with minimum damage. Having the frequency of picking pomegranate (task W5), which was 117 times in 52 min, and the average weight of one pomegranate (0.28 kg), the productivity of young laborers was estimated as followings:

117 No 52 min-1 × 0.28 kg = 32.7 kg 52 min-1 = 37.7 kg h-1 = 37.7 kg h-1 ×8 h day-1 = 301 kg day-1

When the average yield of pomegranate is 22000 kg ha-1 and it should be harvested in 12 days, around 1834 kg pomegranate should be harvested every day. Accordingly, the gardener needs 6 (1834/301) laborers from young group (20-35 years) to harvest a one-hectare pomegranate garden in 12 days.

With similar calculations, the productivity of middle-aged laborers was estimated as followings:

90 No. 52 min-1 × 0.28 kg = 25.2 kg 52 min-1 = 29 kg h-1 = 29 kg h-1 × 8 h day-1 = 232 kg day-1

Accordingly, 8 (1834/232) laborers will be required from the middle-aged group (36-55 years) to harvest a one-hectare pomegranate garden in 12 days. It should be emphasized that all the necessary allowances were considered in the final calculations and the suggested number of laborers can be employed considering their times for personal necessities. In addition, the gardener would have an actual expectation from the laborers to finish harvesting tasks in the given time. Especially when it is emphasized that the estimated values of the normal and standard times for the sample laborers had high correlation with individuals working speed of the task W5 (picking pomegranate).

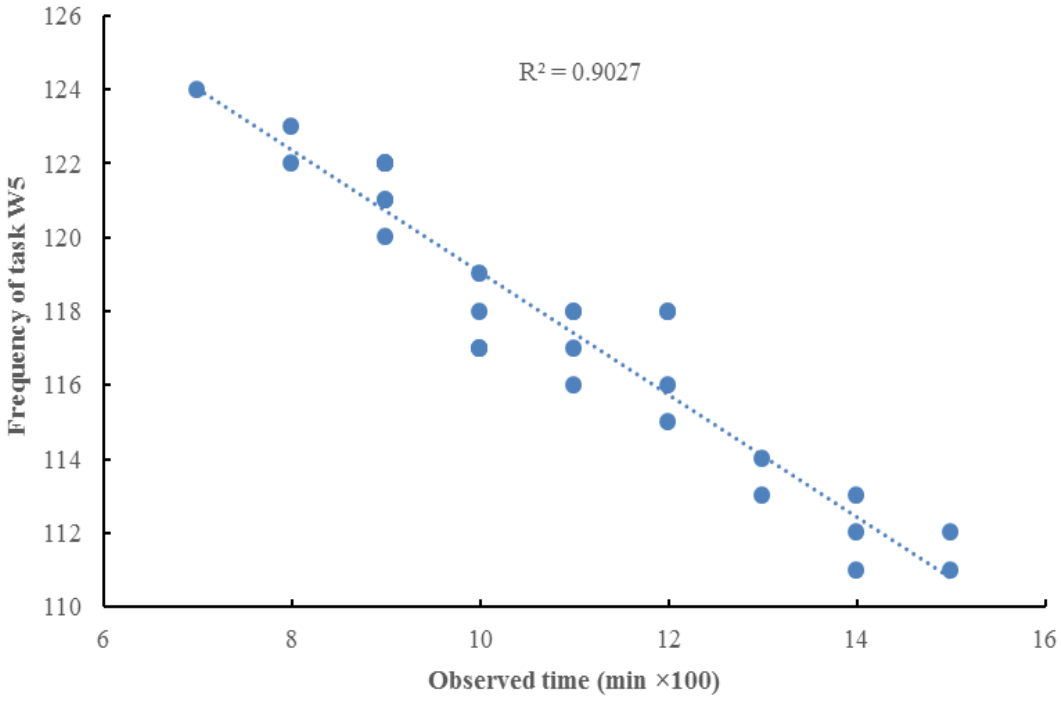


Figure 3 Correlation between frequency and observed time (OT) of task *W5* (picking pomegranates)

3.4 Job satisfaction before and after applying time study technique

Analysis of job satisfaction revealed that middle-aged laborers were dissatisfied with pomegranate harvesting while younger laborers were moderately satisfied with this job before applying time study technique (Table 3). The levels of satisfaction were improved in both the groups after applying time study technique and employing suitable number of laborers.

Around 67% of the middle-aged and 28% of the young laborers were smoking while working. Before application of time study, most smokers argued that they did not have enough time for some rest and smoking. When suitable number of laborers were employed according to the result of the time study technique, the working pressure reduced which led to enhancement of the job satisfaction especially for middle-aged group of laborers.

The level of job satisfaction was significantly different between the two groups before applying time study technique. However, no significant differences were found after applying time study technique meaning that the level of job satisfaction was almost equal in both the groups. A correlation analysis showed a high relationship (94%) between age and level of job satisfaction for middle-aged group of laborers which indicates that allowances were more important for middle-aged laborers. This result is consistent with previous studies in which significant relationships between age and job satisfaction were reported (Izvercian et al., 2016; Steijn, 2004).

Table 3 The level of job satisfaction of pomegranate harvesting laborers

Socio-demographic category	Range	Number of laborers (total = 60)	Job satisfaction before applying time study technique	Job satisfaction after applying time study technique
Age (Year)	20-35	30	83.57 ±0.12 (moderate satisfaction)[a]	108.31 ±0.14 (satisfaction)[a]
	36-55	30	72.29 ±0.34 (dissatisfaction)[b]	105.55 ±0.24 (satisfaction)[a]

4 Conclusion

The enhancement of human's productivity besides preventing work-related fatigues and reaching to a high level of job satisfaction is one the main objectives of any sector/organization. This is the first study in Iran horticulture sector to investigate suitable number of laborers for pomegranate harvesting considering necessary allowances for laborers' personal needs. The data of the time study revealed that the two groups of laborers, i.e. 20-35 years old and 36-55 years old harvest pomegranate with different speeds and, thus, different number of young or middle-aged laborers are required to harvest a one-hectare pomegranate garden. The results showed that there are high correlation between some tasks and the observed time (*W5*: picking pomegranate).

The estimation of the required number of laborers for pomegranate harvesting were accomplished based on the required times for tasks in addition to the allowances, i.e. standard time. Accordingly, a gardener would expect that his/her garden will be harvested on time. Accordingly, the applied methodology led to better farm/garden management (benefit to gardeners) and job satisfaction enhancement especially amongst middle-aged group of laborers (benefit to laborers).

The applied methodology can be applied in other sectors to determine actual number of laborers/workers (considering actual productivity) for a given task. Furthermore, more investigation into other effects of applying suitable number of workers in any job is suggested for future studies. Impacts on the enhancement of laborers' health and safety is essential especially when the laborers know that they can use enough time for personal needs. Furthermore, some higher salaries can be determined when the laborers work with higher speeds than normal time. But, this is not consistent with the purposes of the time study technique which is working with normal speed using suitable rests to have health, safety and satisfaction.

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