Vapo Container Germinant Thinning and Supplementation

LEO TERVO, KARI KAUTTO
Finnish Forest Research Institute
Suonenjoki Research Station
Juntintie 40
FIN-77600 Suonenjoki, Finland

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This research deals with a study conducted on the effect of different work postures on the productivity of container germinant thinning and supplementation. In addition, work strain was also studied by measuring the heart rate of the test subject and work postures were analysed using the OWAS method (Ovako Working Posture Analysing System).

The work was carried out at an hourly rate of 65 FIM per hour including social costs. According to different work methods, the costs of thinning and supplementation varied from 2.5 p to 3.3 p per seeding. In the test subjects' opinions the best work methods were half sitting and standing.

There were no significant differences in working time between the various work methods. Kneeling was the fastest work method but it indicated poorly as regards work posture. The test subjects' average heart rate ranged between 91 and 109 beats per minute.

After thinning and supplementation, 2 % of the containers were empty and 6 % had two seedlings. This result was partly explained by late germination.

Keywords: container seedling production, Vapo-container, germinant thinning, supplementation, work posture, ergonomics.

1 USD = 6.41 FIM = 0.93 €, 1 FIM = 100 p

Introduction

About 150 million seedlings are produced annually in Finland of which 85 % are container seedlings (Finnish Statistical Yearbook of Forestry, 1999). Nowadays in conifer container seedling production single seed sowing is almost exclusively employed which means that container germinant thinning and supplementation are reduced. On the other hand some nurseries have changed from single seed sowing back to double seed sowing. Birch seedlings are mainly produced using the pricking-out method.

The initial growing stage for container seedlings generally takes place in plastic greenhouses. Birch and pine container seedlings are grown for one growing season and spruce container seedlings for one to two growing seasons.

The working conditions in greenhouses differ from most other working environments. In plastic greenhouses temperatures may rise to over 40 °C on sunny days. Also the humidity conditions of greenhouses can be unfavourable for the employee. The thinning and supplementation as well as pricking out of container germinants is generally carried out in plastic greenhouses. The working postures in greenhouse work have been studied a little (Nevala-Puranen et al, 1992), and studies conducted by Nevala-Puranen et al (1992) and Lundqvist et al (1987) deal only with horticultural and greenhouse work.

In this study, the effect of different working positions in container germinant thinning and supplementation was followed for three years. In addition to normal work-study the employee's heart rate was measured as well as the work posture stress, which was analysed using the OWAS (Ovako Working Posture Analysing System) method. The results of the OWAS method can be used in the designing and purchase of machines and equipment. Similarly aspects concerning work safety can be considered and information concerning working postures and environment required by the occupational health service can be produced for possible improvements (Salonen and Heinsalmi, 1987).

Data and methods

Different work methods of container germinant thinning and supplementation were studied at the Suonenjoki Research Nursery of the Finnish Forest Research Institute for three years. In 1988 (A) and in 1989 (B) the methods were 1 (standing), 2 (half sitting), 3a (sit-

ting) and version b (sitting all the time) of method 3. In 1990 (C) the research was supplemented with work methods 2 and 4 (kneeling). The work-study of different work stages was carried out as a normal time study: fetching the seedling box, thinning and supplementation, lifting the seedling box from the rack, returning the seedling box, other work (e.g. moving a pricking-out rack) and moving the seedling box along the ground (method 4). In addition to the time study the employee's heart rate was measured in different work methods by work phases using Medinik Biotelemetry IC-45 equipment, and work movements were analysed on a video tape by using the OWAS method.

Two professional research nursery workers acted as test subjects. Thinning were carried out as hourly paid work, and the data was collected altogether during eight working days per test subject. During the study the greenhouse temperatures varied from +5 °C in the morning to +28 °C at midday. The heart rate varies to some extent during a working day despite the strain remaining constant (Harstela 1979). In this study the working days were divided into as many periods as there were methods to be studied and each method was repeated at different times of the working day.

Before thinning and replenishing, an inventory of 143 Vapo container seedling boxes (13 728 sown places) was made. After sowing, 17.6 % of the containers were empty, 48.5 % had one germinant and 32.9 % had two germinants. A Sator 6 seed drill made by Lännen Tehtaat Oy was used for sowing. The sowing drum had two holes per sowing position. The germination rate of the pine seed was 93 %. The Vapo seedling boxes on average weighed 10.1 kg in the first year and 9.6 kg in the second year.

Work Methods

The work methods to be studied were the following:

Method 1. Standing

The pricking-out rack was adjusted to a suitable work height, and the work was carried out while standing.

Method 2. Half sitting

The test subject was in a half sitting work position. The height of the chair and the pricking-out rack were adjusted to a suitable work height according to the test subject's measurements. A single legged saddle seat was used as a chair, which when sitting was tilted forward and at the same time supported by the feet on the ground. Thus the position was sufficiently steady and the employee was sufficiently close to the seedling box. When standing free, the seat turned backwards so that the seedling box could be placed and removed easily. The seat base was heavy and because of a low centre of gravity the seat stayed upright well. On the other hand, the greater weight made the seat more difficult to move.

Method 3a. Sitting.

The pricking-out rack was adjusted to a suitable work height, and the work was carried out while sitting. As a seat, a normal chair with a backrest was used. The test subject himself fetched and returned the seedling boxes.

Method 3b. Sitting all the time.

The pricking-out rack were adjusted to a suitable work height, and the work was carried out while sitting. As a seat, a normal chair with a backrest was used. The test subject thinned and replenished all the time and the boxes were brought to within his reach. Thus, a method was imitated where the work could be carried out while sitting and the seedling boxes automatically conveyed to within the employee's reach.

Method 4. Kneeling.

The work and moving was carried out in the kneeling position. The knees were protected by kneepads.

OWAS Data

The OWAS system is a method of charting and classifying work postures, which harmfully load the locomotor system. It is used in designing and developing work methods and equipment in order to find the most favourable work postures as regards work health.

The OWAS study data were collected by recording the test subject's work on video. The video material observation interval was 30 seconds and in the third year 15 seconds due to the lack of material. The work posture definition was made as a "blink observation". The videotape was stopped for observation. Each observation consisted of ten variants. The most important variants were the posture data of the back, hands and feet as well as the required force (burden weight). On the basis of this information, improvement classes are obtained which express the priority of the improvement measures. The classification also indicates the work postures, which require no attention. There are four actual improvement classes (Imp-cl).

Imp-cl1. Normal, no action required.

Imp-cl2. Improvement solution required in the near future.

Imp-cl3. Improvement solution required as soon as possible.

Imp-cl4.Improvement solution required immediately.

Back postures were divided into four classes. In class 1 the back is straight with the weight divided evenly on the vertebra (80 %) and joints (20 %). There is no loading on ligaments and the stability of the posture is good. In a crouched posture (class 2) the disk pressure increases to 90° and the ligament strain increases because the joint surfaces separate from each other causing the surrounding tissues to stretch. Muscular strain increases to 45° and the stability of the position reduces. In a twisted posture (class 3) the disk pressure increases because the ligaments tighten. The joint surfaces press together on one side and separate on the other causing tissue strain when the muscles become unevenly loaded and the stability of the posture is poor. When the back is simultaneously bent and twisted (class 4) the disks and ligaments load unevenly and the muscular support for the back is at its weakest because the muscular strain is uneven and the stability of the posture is poor.

The hand positions were divided into three classes. In class 1 both hands are below the shoulder level. In class 2 one hand is on or above the shoulder level and in class 3 both hands are on or above the shoulder level.

The feet positions were divided into seven classes. In feet position 1 (sitting) the load is concentrated at the back muscles and ligaments. The immobility can reduce circulation and the static posture may become awkward if sustained. The balance in the sitting posture is good. In feet position 2 (standing) the weight is on the ligaments and joints and the pressure on cartilage surfaces is evenly divided. There is no muscular strain but consistent immobility hinders circulation. The balance of the posture is good. In feet position 3 (standing with weight on one straight leg) the strain on joints and muscles increases because of bad balance. In feet position 4 (kneeling), pressure on knee joints increases muscular strain. The strain on joint surfaces is divided unevenly and the ligament strain increases as the flexion increases. The strain on thigh, buttock and calf muscles increases strongly in the beginning, and the circulation is hindered. In feet position 5 (standing with weight on one leg bent at the knee) the strain on ligaments and muscles is even greater than in feet position 3 because of bad balance. In addition, the circulation in the feet is hindered. In feet position 6 (kneeling posture) the strain is concentrated at the knee joint when the knee mucous bursa is irritated and the ligaments become strained. The posture is stable but if sustained, circulation is hindered. Feet position 7 (walking) is varied but the motion may make the posture unstable.

Statistical analysis of the OWAS data

The dependency between different work methods and improvement classes was tested using the X^2 test and then by calculating, by method, the squares of both the observed and the expected (according to the independency hypothesis) frequency correlation factors (R^2) in the different improvement classes. The factors define, on a scale 0-1, how well the independency hypothesis explains the variation in the observed data (Palmgren, 1989).

Results

Use of work time

In the first year (A) the methods 1 (standing), 2 (half sitting) and 3a (sitting) were studied. The test subject 1's use of work time in different work methods was constant. For both test subjects, method 1 was the fastest and for test subject 2, the use of time was approximately 10 % less than in methods 2 and 3a. In the second year (B), method 3b (sitting all the time) was studied in addition to the previous year's work methods. In method 3b the test subject thinned and replenished all the time, and the boxes were brought to within his reach. For test subject 1, the use of time per box was the greatest in method 3a. For test subject 2, the use of time was least in method 3b. For the first and second years the order of speed of methods used was the same for both test subjects. In other words, method 1 was the quickest. For test subject 2 the beneficial difference of method 1, however, was not as great as the first year. In the third year (C) methods 2 and 4 (kneeling) were studied. For both test subjects the use of time in method 4 was less than in method 2, more clearly for test subject 2 than for test subject 1 (Figure 1).

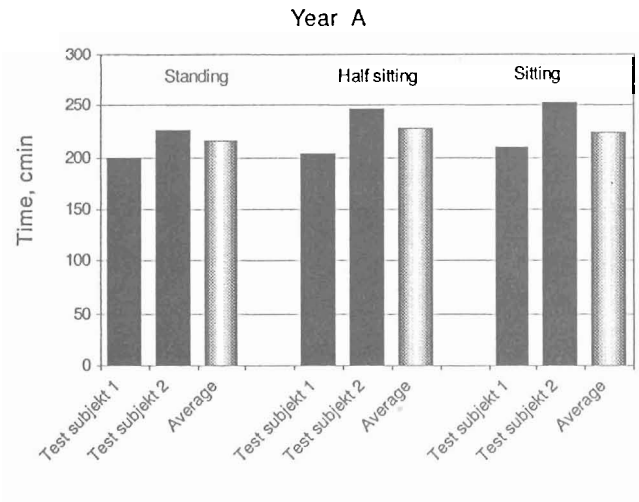
Work strain

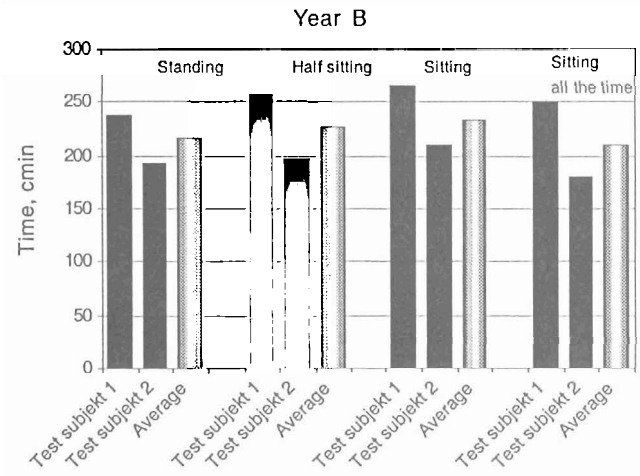
The test subject's average heart rate was calculated weighed by the duration of different work phases. The weighed heart rate varied in different work methods 95105 times per minute for test subject 1, and 91109 times per minute for test subject 2 (Figure 2).

Classification of work postures by the OWAS method

Back postures

Of the studied work over 85 % was actual pricking out work. The fetching and returning of the box took about 14 % of the work time and the share of other work (e.g. moving a pricking-out rack) was only about 1 %.





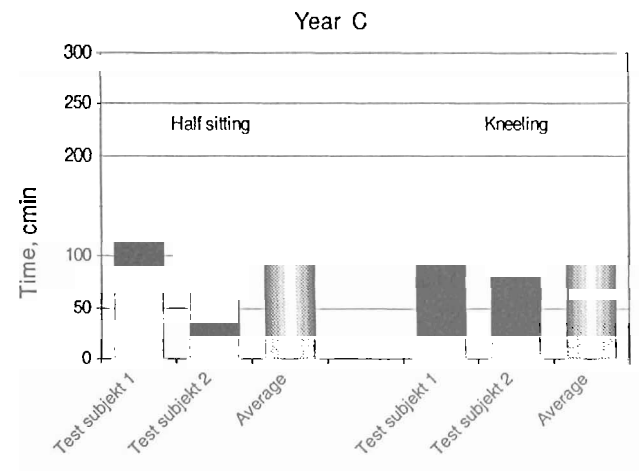
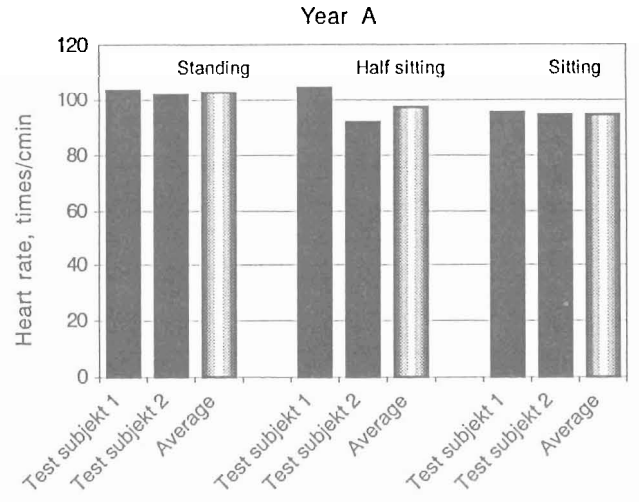
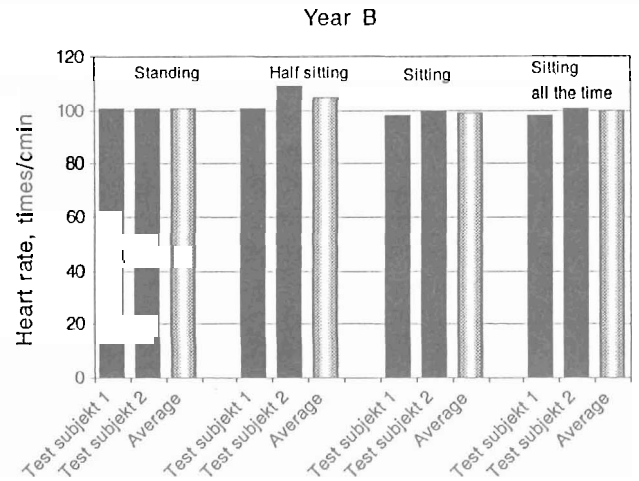


Figure 1. Use of work time (cmin/seedling box) by test subjects and methods in the years A, B and C. (100 cmin = 1 min).





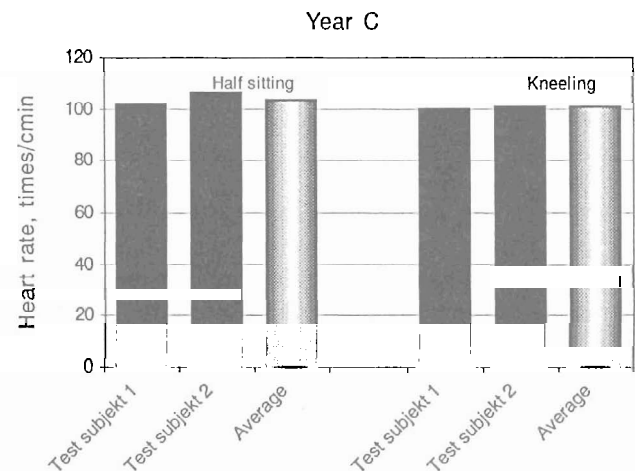


Figure 2. Test subjects' average heart rate weighted by work stages (times/min) by work methods in the years A, B and C.

In methods 1-3a, there were no significant differences in the different back postures (Table 1). An exception was method 1 in the first year when one test subject worked unusually much with the back bent. The test subject checked the seedling box after pricking out by bending closer to the box to see the germinants better. In the second year, this work approach was not used. Back bending postures (bent and twist-

Table 1. Test subject's OWAS classified back postures in different work methods. Values are the averages of years A-C

	Back postures, %			
Work method	Straight	Bent	Twisted	Bent + twisted
1 (standing)	89,1	10,7	0,1	0,0
2 (half standing)	89,9	9,5	0,5	0,2
3a (sitting)	89,6	9,3	0,5	0,6
3b (sitting all the time)	93,0	3,2	0,4	3,4
4 (kneeling)	2,2	90,6	0,1	7,1

ed) were mainly caused by fetching and returning the box. In method 3a (sitting), setting the box in the rack and lifting it from the rack demanded reaching because the test subjects did not move the chair far enough from the rack after thinning. In method 3b (sitting all the time), the lifting and moving of the box from the side table to the pricking out rack caused twisted back postures. A side table was used for technical reasons as it was desired to simulate a situation where the transport would be carried out by, for instance, a conveyor. Thus, the share of thinning and supplementation would be made to increase, and at the same time the back straining postures would decrease. In the third year, methods 2 (half sitting) and 4 (kneeling) were studied. In method 2 (half sitting), the achieved results were similar to the results of previous years. Instead, the work positions in method 4 (kneeling) differed significantly from the corresponding results of other work methods. When working in the kneeling posture, the back was in a bent position over 90 % of the whole work time. Bent and twisted postures were 7 % of the work time. Therefore the back was straight for only less than 3 % of the whole work time in the kneeling method.

Hand positions

The hands were below the shoulder level (class 1) apart from a few exceptions. Only in ten observations was one hand above the shoulder level (class 2), which means less than 0.1 % of all observations. The hand positions strain the cervical spine and shoulder muscles only in static positions and only when the upper arm is away from the body. There were no static hand positions. Neither did there occur work postures where both hands were on or above the shoulder level (class 3).

Foot positions

In work methods 1, 2 and 3, there were no significant differences in positions of the feet (Table 2). In methods 1-3a, the differences in foot positions had only a minor effect in the improvement classification

Table 2. OWAS classified foot positions in different work methods. Values are the averages of years A-C

	Foot positions, %						
	Sitting	Standing on two feet	Standing on one feet	Crouching on two feet	Crouching on one feet	Knee	Walking
1 (standing)	0,0	91,2	0,0	2,5	0,0	0,0	6,2
2 (half standing)	81,6	8,4	0,0	3,7	0,0	0,0	6,3
3a (sitting)	84,2	6,3	0,0	3,0	0,0	0,0	6,5
3b (sitting all the time)	94,1	5,2	0,1	0,2	0,0	0,0	0,5
4 (kneeling)	0,0	0,1	0,0	0,1	0,0	99,1	0,7

between methods (table 3). In work method 3b (sitting all the time), the crouching postures when fetching and returning the box were eliminated. As 99 % of the work time, in method 4 (kneeling), was spent in the kneeling posture, the employees used kneepads. Although the knees are protected from major strain, the duration of the work strains the joints and ligaments as well as hinders circulation. In addition, as in 90 % of the work time the back posture was bent and 7 % bent and twisted the work postures of the kneeling method were clearly the most strenuous and wearing of the five methods studied.

Table 3. Improvement class distribution (Imp-cl) and observed and expected frequencies in different improvement classes. Values are the averages of years A-C

Work method	Imp-cl1	Imp-cl2	Imp-cl3	Imp-cl4	Total
1 (standing)	89,2 %	8,0 %	2,8 %	0,0 %	100 %
observed frequencies	2589	231	81	0	2901
expected frequencies	2246	540	84	31	2901
2 (half standing)	90,3 %	5,6 %	4,1 %	0,0 %	100 %
observed frequencies	3949	243	180	1	4373
expected frequencies	3386	814	126	47	4373
3a (sitting)	90,1 %	6,5 %	3,4 %	0,0 %	100 %
observed frequencies	2584	186	99	0	2869
expected frequencies	2221	534	83	31	2869
3b (sitting all the time)	93,4 %	4,3 %	2,3 %	0,0 %	100 %
observed frequencies	1815	83	45	0	1943
expected frequencies	1504	362	56	21	1943
4 (kneeling)	2,3 %	90,3 %	0,2 %	7,2 %	100 %
observed frequencies	48	1899	5	151	2103
expected frequencies	1628	392	61	23	2103

In work methods 1, 2 and 3, different improvement classes did not significantly differ from each other (R^2 = 0.96098). Apart from kneeling, about 90 % of the work postures belonged to improvement class 1 (no action required). When using these methods, less than 10 % of the work postures belonged to improvement class 2 (improvement solution required in the near future). Improvement class 4 (improvement solution required immediately) did not occur in any of these methods. Kneeling (method 4) differed significantly from other

work methods ($R^2 = 0.02$) because less than 3 % of its work postures belonged to improvement class 1, over 90 % to improvement class 2 and over 7 % to improvement class 4 (table 3).

Quality of work

After the thinning and supplementation an inventory of 51 Vapo seedling boxes was made and on average about 2 % of the containers were empty, 92 % had one seedling per place and 6 % had two seedlings per place.

Costs

Work was carried out at hourly pay. The test subject's hourly cost was 65 FIM (incl. social costs) according to the wage level in the year 2000. At the average output of the test subjects the cost of thinning and supplementation is 2.7 p per seedling in method 1; 2.5 p per seedling in method 2 (owing to the work time used the cost in the first two years was 2.8 p per seedling); 2.8 p per seedling in method 3a; 3.3 p per seedling in method 3b 1) and 2,1 p per seedling in method 4.

1) In method 3b an assistant is required to bring seedling boxes to the conveyor. The cost does not include the capital costs of the conveyor.

Examination of the results

There was no significant difference between the standing posture and the different sitting postures as far as the use of work time was concerned. In the third year, the test subject's use of work time in method 2 (half sitting) were about 20 % less than in the previous years. There were no significant differences in the heart rate of the test subjects in the different methods. For test subject 2, the use of work time in the second year is explained by a low heart rate. The heart rate corresponded to that of medium heavy work and was partly caused by temperature stress. Therefore, there is significance in lowering loading. In the knee posture (kneeling), the use of work time was the least but because of bad work posture, the knee posture can be recommended only for part-time work in connection with work rotation.

In this study there were no significant differences in hand positions between different methods. As far as the work postures are concerned, kneeling was the worst of the studied methods. It was essential to alternate work postures in each different work methods. In the test subjects' own opinions, half sitting and standing were recommendable work postures.

The quality of work was determined by making an inventory of the seedlings after thinning and supplementation. Since 2 % of the containers were empty and 6 % of the containers had two seedlings per place, the result can be considered to be only satisfactory. The two-seedling figure can partly be explained by late germination. After Herranen (1988) the single seed seeding method can theoretically reach a seed and work cost saving of about 20 000 FIM per million seedlings. In the study by Herranen (1988) the seed germination was 94 % and the share of empty containers was 4.9 %. After Turunen et al (1987) the supplementation of empty containers is recommended to be carried out from containers in neighbouring sheets. Transfer supplementation should be carried out within 2–3.5 weeks from sowing, thus avoiding malformation of roots which would possibly hinder germinant development. In assessment of thinning and supplementation, the economic comparison, for instance, with single seed sowing is not sufficient. The quality of seedlings as a whole, and particularly that of supplement containers, should be considered.

The costs show that the most expensive method was 3b (sitting all the time) and the most economical was method 4 (kneeling). Between the other methods, the differences were small, but even small differences are significant when handling millions of seedlings. It is not worth "growing" empty containers.

References

Harstela P. 1979. Puunkorjuun ergonomia. Suonenjoki 1979. 151 s. (In Finnish)

Herranen T. 1988. 1-siemenkylvön käyttö taimituotannossa. Metsähallitus. Kehittämisjaosto. Seloste 5/88. 5 s. (In Finnish)

Lundqvist P., Löfstedt B., Gustafsson B., Lindgren G., Brunsson A. & Persson M. 1987. Arbetsmiljö i växthus. Del 6. Arbetsfysiologiska mätningar i klimatkammare och växthus. Institutionen för lantbrukets byggnadsteknik (LBT) Rapport 56. 82 s. (In Swedish)

Metsätilastollinen vuosikirja. 1999. Skogstatistisk årsbok. Finnish Statistical Yearbook of Forestry. Metsäntutkimuslaitos. (In Finnish)

Nevala-Puranen N., Koivisto T. & Ojanen K. 1992. Kasvihuonetyön fyysinen kuormittavuus. Kuopion alue työterveyslaitos. Raportti 7. 20 s. (In Finnish)

Palmgren J. 1989. Liikenneturvan tutkimuksia. 90/1989.

Salonen A. & Heinsalmi P. 1987. OWAS-työasentojen havainnointijärjestelmä. Työturvallisuuskeskus. Koulutuskansio. (In Finnish)

Turunen P., Kuusela J. & Huurinainen S. 1987. Männyn kennotaimiarkkien täydennys. Metsähallitus. Kehittämisjaosto. Koeselostus n:o 244. 5 s. (In Finnish)

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ИЗРЕЖИВАНИЕ И ПОПОЛНЕНИЕ СЕЯНЦАМИ КОНТЕЙНЕРОВ ВАПО

Л. Терво, К. Каутто

Резюме

Целью данноой работы является изучение влияния рабочей позы человека на продуктивность работы при изреживании и пополнении сеянцами контейнеров. Дополнительно изучалась напряженность работы путем измерения ритма сердцебиения, используя для этого OWAS метод (система изучения рабочей позы Овако).

Работа проводилась при часовой оплате 65 FIM, включая социальное страхование. В зависимости от метода работы, себестоимость изреживания сеянцев в контейнерах и пополнения сеянцами пустых контейнеров составляет от 2,5 до 3,3 центов за один сеянец. Среди изученных методов работы наилучшей оказалась работа стоя и полусидя. При различных методах работы не установлено достоверных различий во времени при выполнении тех же самых операций.

Рабочая поза на коленях была самым быстрым методом работы, однако эта поза была самой мучительной. Средняя скорость сердцебиения составляла между 91 и 109 ударов в минуту.

После изреживания и пополнения сеянцами контейнеров, 2% контейнеров все-таки остались пустыми, а 6% - с двумя сеянцами. Это частично связано с неравномерным всходом семян.

Ключевые слова: сеянцы в контйнерах, Вапо контейнер, изреживание, пополнение, рабочая поза, эргономика.