CASE STUDIES

Ergonomic solutions in tomato harvesting and post-harvest handling

1. Description of the case

1.1. Introduction

This case study is based on an ergonomic study carried out in a small company specialised in growing vine tomatoes and some other varieties. It concerns a family company, lead by three brothers and employing six permanent workers. The company produces yearly about 1.600.000 kg of vine tomatoes. During the harvest season (April - September) about eight to nine additional seasonal workers join the company. This study focused on the harvesting and post-harvesting activities in the company.

Vine tomatoes are grown in greenhouses (with a surface of about 11.000 m^2). The plants are grown as a vine and trained up vertical lines to support them. Every plant produces about 30 clusters of tomatoes.

The last two years some adaptations were implemented in the workplace, related to the following activities:

- picking of tomatoes, and putting them in card boxes (90%) or plastic crates (10%);
- transportation of the boxes or crates to the weighing installation;
- weighing of the boxes or crates;
- stacking of the boxes or crates onto pallets;
- transportation of the boxes or crates to the truck.

The specific adaptations will be discussed in this case study, comparing the situation before and after.

1.2. Aims

Tomatoes are delicate fruits and need to be sent to the market quickly. If they are not handled carefully they decay easily, which affects their taste, flavour and nutritional value (van Dam et al., 2005). The harvest and post-harvest handling of tomatoes is manual and labour intensive work. During the season (from April to September) the work rhythm is extremely high. About 18 workers harvest and handle a total of 1.600.000 kg of vine tomatoes. As this work involves a lot of repetitive movements, lifting, pushing and pulling, there is a high risk for developing musculoskeletal disorders.

In order to reduce the physical workload and production time, new working methods and equipment were installed. The company pays a lot of attention to the working conditions of its employees. As the three brothers, who are the employers, are participating themselves completely in the work, they are very well aware of the difficulties the employees are dealing with. Another aim of the changes was to increase the production capacity. The management also cares about the company's image. Innovation, attention for the environment and occupational safety and health are important values in this 'family company'. The purpose of this study was to give the company an objective and expert analysis and judgement on the impact of the measures that had been taken to improve the working environment and conditions.

1.3. What was done, and how?

1. Measures to improve the harvest

The company invested in new, sharp cutters to cut off the tomatoes. The cutters allow to work with the wrist in a neutral position, which can be considered as positive. The OCRA method (Assessment of Exposure to Occupational Repetitive Actions of the Upper Limbs; ISO 11228-3:2007) was applied to evaluate this repetitive workload. The method gives a Recommended number of Technical Actions per minute (RTA). The RTA calculated for this situation was 15,2. The Actual Number of Technical Actions per minute is 8. The risk score is calculated based on Actual Number TA / RTA, in this case 8 / 15,2 = 0,52. This means there is no risk (there is low risk from a risk score of more than 2,3).

In the past the workers used a low pushcart on which the boxes and crates of 5,5 kg were loaded (see picture 1). The handle had to be removed to stack the boxes or crates. Risks related to the cart were the low height (25 cm) and the fact that the boxes or crates had to be pushed to make place for the next pile (in total 6 boxes in a pile) and to take the empty boxes. An evaluation with the NIOSH Lifting Equation (NIOSH, 1994), demonstrated that the Recommended Weight Limit of the boxes was taken into account the horizontal and vertical distance to lift 4,8 kg. The Risk Score is calculated by dividing the Actual Weight of the load by the Recommended Weight Limit. This Risk Score has to be lower than 1. This means that the actual weight (5,5 kg) was the risk score 5,5 / 4,8= 1,14, which is more than 1. A participatory risk analysis revealed that the workers experienced this activity as a risk for back problems. Pushing and pulling of the filled boxes and crates was also experienced as heavy by the workers.

Picture 1: Old cart

In order to improve this situation, the company has bought new carts (see pictures 2 and 3). On such a new cart the empty boxes (300 gr.) are presented on a higher level, which makes that boxes can be taken very easily. The worker can put the picked tomatoes in the box on an adapted height (always the same level). He can work seated or standing, by adapting the height of the empty box. Once a box is full, he will put this box on the pile just behind. A roller conveyor on the cart allows to push a pile of six filled boxes very easily and without using any force.

The application of the NIOSH Lifting Equation results in the following Recommended Weight Limits (RWL) for the new situation:

- the lifting movement always starts on the same spot; taking into account the frequency of one box per minute, the RWL is 10 kg – Risk Score 5,5 / 10 = 0,55;
- lifting the box to the upper layer or the highest level, with a frequency of one box per six minutes, the RWL is 6,3 kg- Risk Score 5,5 / 6,3 = 0,87;
- lifting the box to the lowest layer or level, with a frequency of one box per six minutes, the RWL is 9,2 kg – Risk Score 5,5 / 9,2 = 0,59;
- lifting the box taking into account the average level, with a frequency of one box per six minutes, the RWL is 5,8 kg – Risk Score 5,5 / 5,8 = 0,94.

This means that according to the NIOSH Lifting Equation, this lifting activity, with an actual weight of 5 to 6 kg, can be considered as ergonomically safe (risk scores are less than 1). The participatory risk analysis revealed that the employees experience this new cart as an important improvement as well.

Picture 2: New cart (working in a standing position)

Picture 3: New cart (working in a seated position)

2. Measures to improve the transport to the weighing installation

In the past a worker pushed the carts, manually and one by one, to the weighing installation. The frequency was about 80 times a day. In a next step, the boxes were pushed on a conveyor to the weighing machine. The participatory risk analysis showed that the pushing of the carts to the weighing installation was a major problem. The KIM (Key Indicator Method) for Manual Handling was used to evaluate this activity. The result of the KIM evaluation was a score of 20, which means that a redesign of the workstation had to be considered.

The new carts require less effort. The carts are moved progressively between the tomato plants. Because the carts are fixed on 'rail system', only a minimum of force is required to push or pull the cart (see picture 3). The weight of a full cart can be estimated at 300 kg (200 kg of tomatoes and 100 kg of the cart). Today a full cart (1,5 full carts per hour per worker) is pushed on the side (not to the weighing installation). Another worker collects the carts with a scooter, and brings them to the weighing installation, where the carts are fixed to the other carts. The machine pulls the carts automatically to the depalletiser. The depalletiser (cost 47.000 €) takes six boxes and pushes them to the conveyor, which brings the boxes to the weighing machine. The manual pushing of the carts and boxes has thus disappeared in the new situation (see pictures 4 and 5). The workers consider this as an important improvement.

Picture 4: Rail system between the tomato plants

Picture 5: New weighing installation

Picture 6: Conveyor system of the new weighing installation

3. Measures to improve the weighing task

Two workers are working at the weighing machine (see picture 6). Boxes or crates are put automatically on the weighing machine. The weight of a box or crate has to be corrected by the operator by putting in or taking away tomatoes. One operator handles about 200 boxes a day, which means about 4000 movements with the hand or 8,3 Technical Actions per minute (see also OCRA method above). A calculation with OCRA gives a RTA of 9,7. The risk score is 8,3 / 9,7 = 0,85 which means there is no risk. Taking into account the layout of the workstation (height, reach), the neutral position of the wrist, and the required force, this work station and situation can be considered as acceptable.

Picture 7: Weighing of the boxes and crates

4. Measures to improve stacking the crates or boxes on pallets

The boxes are put on piles of 13 to 15 boxes onto the pallets (8 piles per pallet). In the past situation this was a manual task (see picture 8). The frequency was 200 boxes per hour or 3,3 boxes per minute. The main complaints of the workers were lifting the boxes on the highest level and the turning movements, which are a major risk for developing back and knee complaints.

Picture 8: Manual loading of a pallet (before the intervention)

In the new working situation this manual task was eliminated. After weighing, the box is pushed on the conveyor and the machine stacks the boxes automatically onto a pallet (see pictures 9 and 10). In this way also the production capacity has increased. The cost of the stacking machine is 55.000 €.

Picture 9: New stacking machine

5. Measures to improve to transportation on the pallets to the truck

The weight of a loaded pallet can be estimated on 550 to 600 kg. In the past the pallets were pushed manually to the truck with a transpallet over a distance of 15 to 20 m with a frequency of 20 pallets per worker per day. An evaluation with the KIM (Key Indicator Method) for Pushing and Pulling resulted in a risk score of 16. This means that a redesign of the workstation is recommended. Therefore an electric transpallet was bought to replace the manual type. The workers consider this new equipment as an important improvement.

Picture 10: New stacking machine

1.4. What was achieved?

- The new workstations and equipment reduce the risk for musculoskeletal disorders significantly. The lifting, pulling and pushing tasks were adapted or eliminated. These tasks and measurements were evaluated by the use of objective checklists like the Revised NIOSH Lifting Equation, OCRA and KIM.
- The workers also perceived the new equipment and installation as an important improvement of their working environment. The workers were convinced that the employer has taken into account their remarks that were made during a participatory risk analysis.
- The measures that have been taken have lead to an increased production capacity.

1.5. Success factors

- The employers were familiar with the ergonomic problems related to the work, because they participate actively in the production.
- The workers participated in the analysis of the risks and the search for solutions. In this way the workers were very motivated to use the new equipment.

1.6. Further information

Freddy Willems, ergonomist from Prevent, has carried out the ergonomic assessments described in this case study.

1.7. Transferability

The solutions applied in this case are transferable to other harvesting and post-harvesting activities in greenhouses. The way of transporting and weighing can be considered as transferable solutions as well.

The applied methodology is based on a global ergonomic approach, in which objective and subjective information is collected to evaluate risks and to “solve” problems. A participatory approach has the potential to involve people in a more active way.

2. References, resources:

- van Dam B, de Goffau M, van Lidt de Jeude J, Naika S. Cultivation of tomato: production, processing and marketing. Agromisa Foundation and CTA, Wageningen, 2005. Available in English at: http://www.journeytoforever.org/farm_library/AD17.pdf
- ISO 11228-3:2007. Ergonomics - Manual handling - Part 3: Handling of low loads at high frequency
- NIOSH. NIOSH Publication No. 94-110: Applications Manual for the Revised NIOSH Lifting Equation. Available in English at: http://www.cdc.gov/niosh/docs/94-110
- KIM - Key Indicator Method. Available at: http://www.handlingloads.eu/en/site/18/19