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# Ergonomics and psycho-sociological quality indeces in greenhouses, Almería (Spain)

A. J. Callejón-Ferre*, J. Pérez-Alonso, J. Sánchez-Hermosilla and A. Carreño-Ortega

*Departamento de Ingeniería Rural. Universidad de Almería, Edificio CITE II-A. C/ La Cañada de San Urbano, s/n. 04120 Almería, Spain.*

## Abstract

This study investigates the use of the Labour Economics and Sociology Laboratory of France (LEST) method to analyse work posts among greenhouse workers in the Almería region of south-eastern Spain. The aim is to improve the health of the labourers. Data were gathered from 110 greenhouses, 73 of the Almería *parral plano* type and 37 *raspa and amagado*. Crops studied were 63 greenhouses of tomatoes, 31 of watermelons, and 16 of courgette, examining the physical environment, physical load, psycho-social aspects, and time worked by the labourers. The main conclusion was that this type of crop protective structure, typical in south-eastern Spain, does not guarantee a comfortable working environment, as defined by the norm UNE-EN 13031-1 reference. The results also associate the different types of greenhouses and their crops with the ergonomic and psycho-sociological conditions of the workers. Improvements are proposed.

**Additional key words**: ergonomics, greenhouse, LEST, prevention, Psycho-sociology.

## Resumen

**Índices de calidad ergonómica-psicosociológica en invernaderos de Almería (España)**

Este estudio investigó el uso del método de LEST (Labour Economics and Sociology Laboratory of France) para evaluar los puestos de trabajo en invernaderos de la provincia de Almería (España). Todo ello, con el fin de mejorar la salud de los trabajadores. Los datos se han obtenido de 110 invernaderos, 73 del tipo Almería "parral plano" y 37 "raspa y amagado"; según el tipo de cultivo, 63 de tomate, 31 de sandía y 16 de calabacín, afectándose negativamente al entorno físico, carga física, aspectos psicosociales y tiempo de trabajo de los trabajadores. Como conclusión principal, este tipo de estructuras de protección de cultivos típicas del sudeste español no garantizan el trabajo de las personas de forma cómoda en su interior, no estando dentro de la definición de la norma UNE-EN 13031-1 de referencia, además los resultados asocian directamente los diferentes tipos de invernaderos y sus cultivos con las condiciones ergonómico-psicosociales de los trabajadores, proponiéndose mejoras para ellos.

**Palabras clave adicionales:** ergonomía, invernadero, LEST, prevención, Psicosociología.

## Introduction

Agriculture in the province of Almería is based on intensive production, technology, work and economics. Thus production, marketing and service systems are continuously being updated, in the province, to prevent them from becoming obsolete and to increase competitiveness.

Greenhouses currently cover nearly 30,000 ha. Over 96% of the buildings belong mainly to the Almería *parral plano* and the Almería *raspa* and *amagado* type (Fernández and Pérez, 2004) and consis-

* Corresponding author: acallejo@ual.es
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All authors are members of the SEA.

Abbreviations used: ANACT (Agence National pour l'Amelioration des Conditions de Travail), EWA (ergonomic workplace analysis), LEST (Labour Economics and Sociology Laboratory of France), RNUR (job-profile method by Renault).

tently generate €1,500 million per year (Fundación Cajamar, 2006).

In terms of average minimal data (BOE, 2001) one greenhouse ha means 360 wages per year. If each wage corresponds to the work carried out by an individual, 45,000 people would be employed to work directly in greenhouses, with large numbers of migrants with little qualification for this type of job (Fundación Cajamar, 2006).

$$\text{Persons} = 360\,\frac{\text{day}}{\text{ha}\cdot\text{year}}\cdot 30,000\text{ ha}\cdot\frac{8\text{ h}}{\text{day}}\cdot\frac{\text{year}}{12\text{ months}}\cdot\frac{\text{months}}{4\text{ week}}\cdot\frac{\text{week}\cdot\text{persons}}{40\text{ h}} = 45,000$$

These figures are similar to the official figure of 38,000 people registered by the Social Security Department as farm hands during the 2005/2006 season (Fundación Cajamar, 2006). This accounts for around 45% of the total expenditure per greenhouse ha.

For reference, greenhouses are covered, light structures that protect growing plants using solar power and shelter against cold and other climatic conditions. Further,, the "dimensions of the enclosure allow people to work comfortably inside" (UNE-EN 13031-1, 2002).

Crop cultivation in greenhouses in Almería is based on low-cost greenhouses with poor environmental control. However, due to the need to reduce pesticide use and to adjust production periods to market demand, it is necessary to improve environmental conditions in the greenhouses and the working conditions of the labourers.

Rainbird and O'Neill (1995) state that ergonomics can alleviate disorders, typical in developing tropical countries, such as pesticide contact, biomechanical disorders, and contact with harmful substances other than pesticides.

Agriculture is one of the hardest jobs and presents a high levels of musculo-skeletal disorders, an effect which suggests that ergonomic risk factors are involved, since traditionally ergonomic criteria have had little application to farm work (Meyers *et al*. 1997).

Litchfield (1999) identifies risks in agriculture work, such as: cuts, bruises, deep wounds, broken limbs, amputations, spinal-marrow injuries, fatal injuries, contact with micro-organisms, contact with pesticides, pain, stress, and injuries resulting from ergonomic problems due to poor working procedures and conditions. Litchfield (1999) states that statistics show one of the highest levels of accidents and injuries of all economic sectors, highlights the relevance of economic costs incurred through temporary sick leave in the agricultural sector and concluded that it was necessary to improve these health statistics through better worker training and accident-prevention programmes.

Health problems suffered by female farm workers in Nigeria include muscle fatigue, fever, dermatitis, migraine, respiratory diseases and sight and hearing problems as a consequence of being exposed to extreme temperatures, pesticides, fertilizers, dust, and insect bites. It is recommended that agricultural policies in developing countries should focus on ergonomic measures to improve the quality of life of farm labourers (Egharevba and Iweze, 2004).

In rural areas, hard work, accidents and traumatic injuries are major concerns of the Indian government, and therefore it is urgent to improve ergonomic conditions in such areas. Further, the lack qualified workers is a concern with respect to crop mechanisation, as this could provoke more serious accidents (Nag and Nag, 2004).

García and Padilla (2005), in a study on preventing work risks in Almerian greenhouses, concluded that variable environmental conditions can be extreme, and could have a negative effect on worker health and increase the risk of accidents. Likewise, these authors indicate the need to be mindful of risks in the way work is organised and in personal relationships among workers of different nationalities, since conflicts can arise due to cultural and linguistic differences.

Li *et al*. (2006) showed that not only professional arthritis is relevant with regard to cost, but also psychosocial problems and work-related factors which affect indirect costs.

Having started a relatively short time ago, studies on work-risk prevention in rural areas are becoming a main line of research in the USA (Frank *et al*., 2004) and the rest of the world. Examples include: studies on the physiological responses, productivity, and assessment of the effort in relation to an agricultural tool (Sen and Sahu, 1996), development of a sickle for growers in Indonesia (Sutjana *et al.*, 1999), improvement of seats for labourers in tomato plant growing nurseries (Okano *et al.*, 2001), improvement in communication and active participation of owners and labourers in apple harvesting (Fulmer *et al*., 2002), improved mechanization of a cabbage crop for better ergonomic efficiency in management and labour (Hachiya *et al*., 2004), improved communication to reduce musculo-skeletal risk among people working with fresh vegetables (Chapman *et al*., 2004), design of a new belt for apple cultivation (Earle-Richardson *et al*., 2006) and introduction of frequent, short breaks (5 additional minutes per hour of work,

which add up to 20 minutes of rest per day) to improve living conditions for those working with strawberry and citrus crops (Faucett *et al*., 2007). Prevention strategies and intervention measures in workplaces must take into account physical factors, as well as the personal characteristics and the labourers' lifestyle (Pinzke, 2003; Costa, 2004).

The minority condition (hispanic immigrants) in the construction sector and low-skilled labour force is an indicator of work accidents. In the construction sector, in the USA, this is being related to worker affiliation or non-affiliation to trade unions (Anderson *et al*., 2000).

Davis and Kotowski (2007) detected high levels of back and shoulder disorders of the upper limbs in farm workers, demonstrating the need for urgency to improve and validate studies on reducing risk and improving farm-worker health in the USA, focusing on the migrant population. At the same time, a lack of understanding of musculo-skeletal disorders, caused by agricultural work, hinders efforts to prevent these types of injuries.

In developing countries, ergonomics reduces fatigue and improves worker satisfaction in rural areas (McNeill and Westby, 1999). Consequently, research and ergonomic programmes are extremely necessary (Kawakami *et al*., 1999; Jafry and O'Neill, 2000). O'Neill (2000) states that deficient implementation of ergonomics in rural areas of developing countries is due to the limited infrastructure in these countries, thus necessitating greater help from developed countries. O'Neill (2005) cites the lack of ergonomic knowledge as causing a lack of improvement in workers' lifestyle in rural areas of developing countries.

Burdorf (1992), argued that most studies on back disorders have poor-quality data and recommended that quantitative methods should be developed for application to work-related diseases. Later, Malchaire (1995) described methods used to assess the main parameters such as temperature, humidity, light, air speed, metabolic level, working clothes, perspiration level, and cardiac rhythm but advised that, because of the complexity of the methods (quantitative or qualitative), workers should cooperate with data collection and analysis and later help to identify and implement solutions (Zalk, 2001). Nevertheless, Malchaire *et al*. (2002) developed models of risk prediction of disorders caused by exposure to high temperature. Also, to measure bullying at work, Willingstorfer *et al*. (2002) believes that it is necessary to interview and/or develop questionnaires for people who have suffered this type of harassment, in order to later quantify the data.

Rugulies *et al*. (2004) suggests a psycho-social analysis of the work environment and a long questionnaire for musculo-skeletal disorders, warning of the lack of normalisation and the methodological limitations of this type of research. Surveys should be made by an interdisciplinary group, examining the following aspects: physical workload, socio-demographic and anthropometric characteristics, social relationships, life events, health, and the physical and psychological condition of the individuals. An interdisciplinary approach aids implementation of a good questionnaire, which can provide reliable information on the psycho-social aspects of the workers so health disorders can be avoided.

Different types of work, such as services, agriculture, industry, and construction vary in their tasks and timetables. This requires an evaluation of the risk of each post. For this, surveys are recommended for ergonomic psycho-social analysis (Gold *et al*., 2006).

As an example of the value of ergonomics, Intel employees in Israel started to complain of wrist aches, and the problem was rapidly investigated and ergonomically resolved, not only in this factory but in all those belonging to this group worldwide (Morag *et al*., 2005).

Another significant achievement was mentioned by Lotter (2003), who directly linked agriculture that respects the environment with ergonomic psycho-social problems of the workers, since biological farming is concerned not only about food but also about how to grow it.

Stanton and Young (1998) quantified over 60 ergonomic procedures and/or assessment methods for the workplace. There are numerous methods, which can be objective, subjective, or mixed, some present slight improvement over the others. The following are worthy of note: the method of the Labour Economics and Sociology Laboratory of France, known as LEST (Guélaud *et al*., 1975), the RNUR or the job-profile method of Renault (1976), the method Agence National pour l'Amelioration des Conditions de Travail, known as ANACT (Piotet and Mabile, 1984), the FREMAP mixed method (Fundación MAPFRE, 1995), the FAGOR method (1987), the Ergonomic Workplace Analysis, known as EWA (FIOH, 1989), the method to investigate cumulative traumatic disorders of the upper limbs (McAtamney and Corlett, 1993), method to evaluate risk factors for musculo-skeletal work-related disorders (Wells *et al*., 1994), the method of identifying ergonomic risk (Kemmlet, 1995) and the Suzanne Rodgers method (Rodgers, 1993).

Torres and Rodríguez (2007) conducted an ergonomic assessment of jobs in the Ecuador fishing industry using the LEST method from among LEST, RENAULT, FAGOR, EWA and ANACT. They performed a discriminating analysis among them, grading each method according to "approximate time of assessment", "variables to assess", "tools used", "analysis of the results" and "applications". They concluded that "physical load" is a major factor in worker fatigue in the fishing industry and is exacerbated by long work hours and ambient noise.

In the horticultural production areas of Almería, there is no history of using methods that show the degree of ergonomic psycho-social quality in a greenhouse in terms of its overall characteristics. This paper is a pioneering study of this sector and aims at determining and quantifying the degree of ergonomic psycho-social quality in greenhouses of the type used in Almería.

## Material and methods

This study was carried out in intensive horticultural farming plots under plastic cover in the province of Almería, Spain (Figure 1).

Labourers on these farms spend 80% of their time inside greenhouses (Figure 2) sowing and/or transplanting, staking plants, pruning, fertilizing, applying pesticides, and harvesting, among other tasks (García and Padilla, 2005).

The data are from 110 greenhouses recorded between 8:00 am and noon, between 21 December 2007 and 20 May 2008 and covered a total greenhouse area of 89.17 ha. The results from the greenhouses differentiate between tomato (*Solanum lycopersicum* L.), watermelon (*Citrillus vulgaris* Schrad), and courgette (*Cucurbita pepo* L.) crops, and between two types of greenhouses: "*Raspa* and *Amagado*" and "*Parral Plano*" (Figure 2).

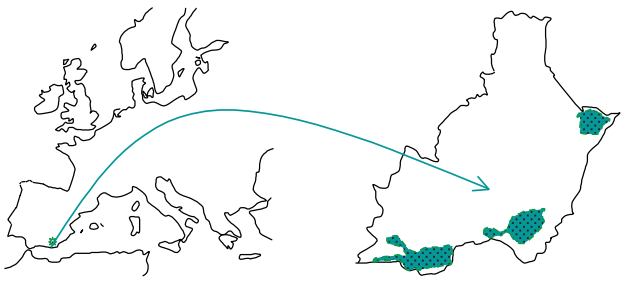

**Figure 1.** Location of 80% of the greenhouses.

The LEST method (Guélaud *et al*., 1975) was used for ergonomic psycho-social assessment and was selected using the assessment criteria of ergonomic methods of Stanton and Young (1998).

In this method, the working conditions in a greenhouse are described objectively to provide an overall view and assess the jobs and working conditions, to be used as a basis for an improvement programme for workers. Implementation does not require specific knowledge and was designed so that the entire staff involved could participate in all the stages of the process (Fundación MAPFRE, 1995).

It is arguably an ideal method to study the physical and mental workload and metabolic expenditure, but it is not as appropriate to analyse the potential risk of injury caused by cumulative traumatic disorders (Fundación MAPFRE, 1995).

Data were collected through personal interviews with farm workers and/or farm owners, as well as with technical staff who act as consultants to the farms. The questionnaires, as Rugulies *et al*. (2004) pointed out, were not normalised, presenting methodological limitations in this type of research. Therefore, 16 non-defining criteria were adopted in the observation guide, clustered into five relevant aspects (Guélaud *et al*., 1975):

a) Physical environment: thermal environment, lighting, noise and vibrations.

b) Physical load: static and dynamic.

c) Mental load: time pressure, complexity-speed, attention, and thoroughness.

d) Psycho-social aspects: Initiative, social status, communication, cooperation, and identification with the product.

e) Working hours.

One of the main advantages of this method is that a score can be assigned for each variable examined, using a value of 0 to 10 to determine the ergonomic situation of farm concerned in relation to each variable (Table 1).

Simultaneously, a vast amount of data were collected to define environmental parameters, such as, crop type, greenhouse type and irrigation method.

Overall, the collection of objective data required instruments such as a Mavolux 5032C-USB model luxometer (Gossen, Germany), a Questemp$^0$ 36 model environmental thermal monitor (Larson Davis, USA), a HVM-100 model vibrometer (Larson Davis, USA), a measuring tape, and a chronometer. Together with the data collection, an observation guide was prepared to quantify the parameters according to the criteria listed in Table 1. Thus, after an index was assigned to each

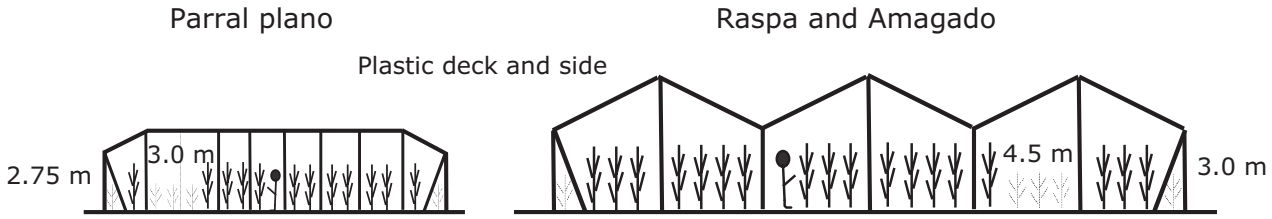


**Figure 2.** Section of average greenhouses in Almería.

parameter (non-arbitrarily and with defined sub-criteria), all the data were subjected to a variance analysis and a significant-minimal-difference test, using the statistical package STATGRAPHICS Plus 4.0 for Windows. Data were validated by normality and homoscedasticity tests.

## Results

Of the 110 farms studied (89.17 ha), 73 were of the "*parral plano*" type (49.04 ha) and 37 were the "*raspa and amagado*" variety (40.13 ha). Each measured between 0.12 and 3.13 ha. In terms of crops, 63 houses grew tomatoes (46.53 ha), 31 grew water melons (31.42 ha) and 16 grew courgettes (11.22 ha).

Workers employed in the greenhouses belonged to two categories, "family" (related to the owner) and "non-family" (not related to the owner). The number varied from 1 to 15, due to the different greenhouse sizes and the level of growth of each crop. Normally, one or two labourers are employed on a regular basis, whereas the rest of the labourers vary in number. This was the case in 90.9% of the greenhouses studied.

Whether owners had preferences when hiring labourers was determined by a question, which in most cases indicated they had no preference, although employers emphasized that the labourers should be thorough and reliable.

All greenhouses had male and female workers (84.5% and 15.5%, respectively), and all started work very early. Tasks were considered monotonous. In 26.6% of the greenhouses in the study labourers were given information on work risks.

Of the total number of labourers, 48.2% were foreigners, during the work this caused conflict among employees in 25.5% of cases.

Although there were Spanish labourers in all greenhouses, 44.5% of the workers were from Morocco and 12.7% from Eastern Europe.

The most common work schedule was from 8:00 to 15:00 hours in 49.10% of cases, though most of them admitted that they also worked until the evening.

In 86.4% of the greenhouses, the work week was from Monday to Saturday, while the remaining 13.6% worked for 7 days a week. The average resting time was 30 minutes per work day.

Figure 3 indicates that the greenhouse work is harsh (Table 1), especially due to high temperatures, cooperation, and working hours, apart from social status, static and dynamic load and identification.

Thus, the physical environment, the physical load, psycho-social aspects and working hours all had negative effects (Table 1), due to fatigue risk (red line in Figure 3).

The parameters working hours, identification, thoroughness, attention, noise, vibrations and dynamic load were constant in all greenhouses studied, regardless of structure type and crop, and are therefore not shown in Table 2.

Analysis of the remaining parameters and comparing the data from the two structure types, showed significant differences only in for "communication possibilities", "cooperation" and "initiative".

Comparing crops (Table 2) without considering structure type gave significant differences in the parameters "thermal environment" and "static load".

A combined study of structure type and crop yields practically the same results as when examined separately. There was a harsher thermal environment in watermelon crops regardless of structure type.

## Discussion

The present government-sponsored research, in rural areas, is in agreement with the descriptions of Frank *et al*. (2004) and seeks to improve the working conditions of the agricultural workers, as in the case of Sen and Sahu (1996), Sutjana *et al*. (1999), Okano *et al*. (2001),

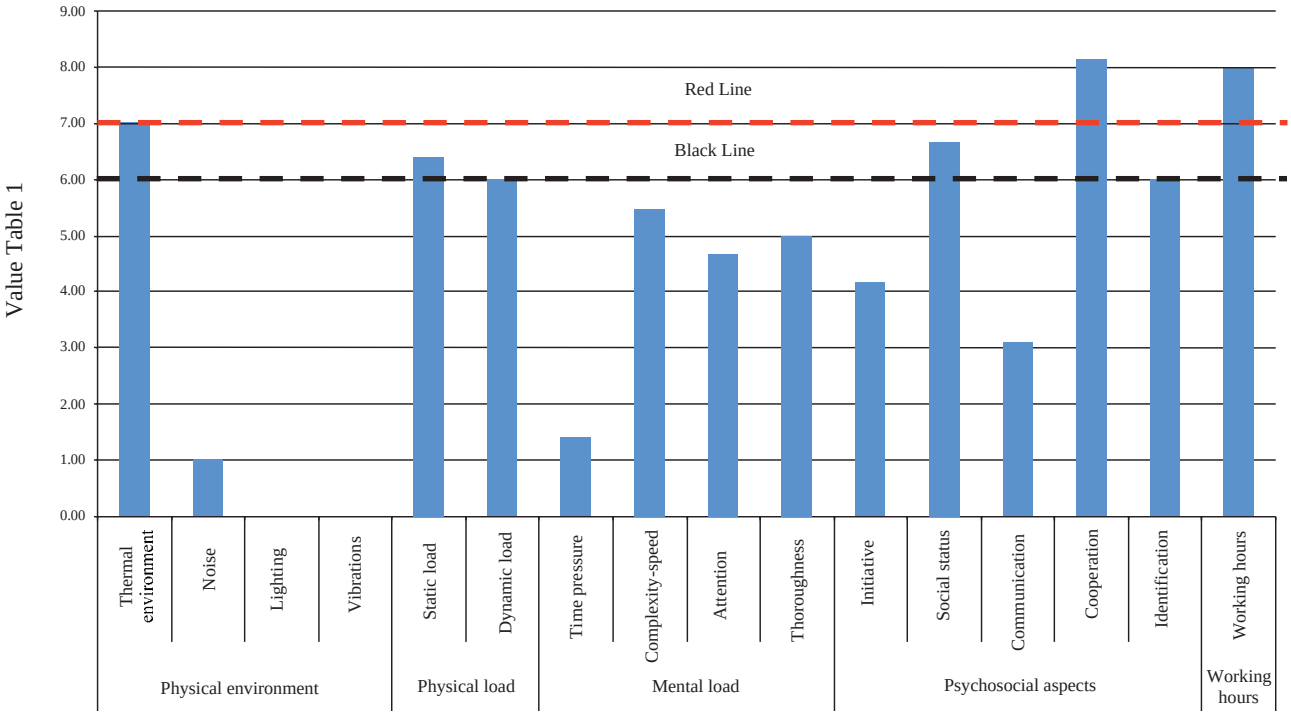


**Figure 3.** Average histogram of all greenhouses studied.

Fulmer *et al*. (2002), Hachiya *et al*. (2004), Chapman *et al*. (2004), Earle-Richardson *et al*. (2006), Faucett *et al*. (2007), Pinzke (2003), and Costa (2004). The results indicate that the greenhouse farming sector is harsh, as found by Rainbird and O'Neill (1995), Meyers *et al*. (1997), Litchtfield (1999), Egharevba and Iweze (2004), Nag and Nag (2004), García and Padilla (2005), Li *et al*. (2006), and Davis and Kotowski (2007). Further, there is no guarantee that the dimensions of a house allow labourers to work comfortably inside it, as described in regulation UNE-EN 13031-1 (2002).

The tasks of sowing, transplanting, staking plants, pruning, fertilization, pesticide application and harvesting are simple, as reflected in the results for the mental-load block.

This simplicity, in addition to the work schedule and its harshness, due to environmental conditions, is associated possibly with the hiring of immigrant labourers with few qualifications or resources, as most of them are from developing countries such as Morocco. This indicates, as in the cases of McNeill and Westby (1999), Kawakami *et al*. (1999), Jafry and O'Neill (2000) and O'Neill (2000, 2005), the need to propose ergonomic improvements and work-risk prevention programmes for greenhouse labourers in Almería (Spain), in addition to applying and improving existing ergonomic-assessment methods (Burdof, 1992; Malchaire, 1995; Zalk 2001; Malchaire *et al*., 2002; Willingstorfer *et al*., 2002).

All columns (psycho-sociological and ergonomic parameters assessed by the method) in Figure 3 which are above the red line show, according to Table 1, fatigue, this being the estimated limit to propose the most urgent need for improvements regarding the labourers. The only effective measure to make the most unfavourable parameters admissible (ambient temperature, cooperation and working time) would be to avoid sudden changes in temperature and humidity. For this, labourers should work in shifts of 3 or 4 h and not for a continuous working day, working up to 8 h in other agricultural activities, such as manipulation and packing of fruit and vegetables. In addition, more information on work risks and more measures of integration among labourers and between labourers (foreign or not) and owners would be helpful. Levels of "static load", "dynamic load", "social status" and "identification" would diminish, which, according to Table 1 and Figure 3 (values above the black line), could cause fatigue.

Given that the parameters "working hours", "identification", "thoroughness", "attention", "noise", "vibra-

**Table 1.** Value and purpose, by parameter, of the LEST method (Guélaud *et al.*, 1975).

| Value | Effects |
|---|---|
| 0, 1, 2 | Situation satisfactory |
| 3, 4, 5 | Weak inconvenience. Improvement possible |
| 6, 7 | Nuisance averages. Risk of fatigue |
| 8, 9 | Nuisance strong. Fatigue |
| 10 | Harmful |

tions", and "dynamic load" remained constant, the LEST method appears to be not suitably efficient for this type of work. This may indicate that the method should be re-adapted or that those parameters are not applicable to glasshouse structure and crop management.

Differences found analysing structure type in "communication possibilities", "cooperation", and "initiative" could be due to "*raspa and amagado*" greenhouses being more sophisticated than flat-roofed ones and that work inside them is much more organised. However, values for the parameters "communication possibilities" and "initiative" would be admissible and could be amended (Table 1). "Cooperation" in ridge and valley greenhouses was somewhat worse than in flat-roofed vineyard ones, due likewise to better work organisation. The "Thermal environment" on the other hand, was equally poor in both cases (Table 2). This was because they were not greater than 3.58, provoking slight, easily solved disorders (Table 1).

The significant differences in the parameters "thermal environment" and "static load", only for crops, are justified by the specific tasks required for each crop, depending, for example, on plant height (courgette and watermelon are short but tomatoes are tall). Harvesting is also different and more or less painstaking, especially for courgettes.

When crops were combined with structure type the differences were almost equal to the ones above. Watermelon stood out as the harshest crop due to its need for high humidity and temperature for pollination and because, when transplanted at, the end of winter, cold temperatures should be avoided and heat loss prevented from inside the greenhouse. These can be considered to be crop-management factors on the part of the farmer.

In conclusion, the type of greenhouse structure for crops typical in southern Spain does not guarantee worker comfort as defined by the norm UNE-EN 13031 reference. Therefore, a reduction in work shifts to a maximum of 4 h is advised to make this activity healthier and to complete the working of 8 h in other similar activities. The LEST method should be adapted to this kind of work to assess working hours, identification,

**Table 2.** Variation in ergonomic psycho-social indeces depending on the type of greenhouse structure and crop

| | Thermal environment | Static load | Time pressure | Complexity-Speed | Initiative | Social status | Communication | Cooperation |
|---|---|---|---|---|---|---|---|---|
| *Structure* | | | | | | | | |
| Parral plano | 6.99a | 6.42a | 1.38a | 5.49a | 4.13b | 6.68a | 2.83b | 7.93b |
| Raspa and amagado | 7.07a | 6.37a | 1.49a | 5.45a | 4.25a | 6.63a | 3.58a | 8.54a |
| Significance | ns | ns | ns | ns | * | ns | *** | * |
| *Crop* | | | | | | | | |
| Courgette | 6.39b | 7.13a | 1.31a | 4.81a | 4.17a | 6.69a | 2.88a | 8.13a |
| Watermelon | 8.29a | 7.23a | 1.55a | 5.06a | 4.23a | 6.65a | 3.03a | 8.44a |
| Tomato | 6.48b | 5.81b | 1.37a | 5.84a | 4.14a | 6.67a | 3.17a | 8.00a |
| Significance | *** | *** | ns | ns | ns | ns | ns | ns |
| *Crop and structure* | | | | | | | | |
| Courgette parral-plano | 6.50b | 7.14a | 1.32a | 4.86a | 4.14a | 6.64a | 2.71b | 8.00a |
| Courgette raspa-amagado | 5.50b | 7.00a | 1.25a | 4.50a | 4.33a | 7.00a | 4.00a | 9.00a |
| Watermelon parral-plano | 8.18a | 7.16a | 1.39a | 4.89a | 4.19a | 6.84a | 2.63b | 8.26a |
| Watermelon raspa-amagado | 8.46a | 7.33a | 1.79a | 5.33a | 4.28a | 6.33a | 3.67a | 8.71a |
| Tomato parral-plano | 6.51b | 5.79b | 1.38a | 6.00a | 4.09a | 6.62a | 2.97b | 7.74a |
| Tomato raspa-amagado | 6.44b | 5.83b | 1.35a | 5.58a | 4.22a | 6.75a | 3.50a | 8.42a |
| Significance | ** | *** | ns | ns | ns | ns | ** | ns |

ns, *, ** and ***: not significant or significant for P ≤0.05, 0.01 or 0.001, respectively. Test for minimum significant differences.

thoroughness, attention, noise, vibration and dynamic load. Finally, more training and further measures are necessary to decrease the physical load and psychosocial blocks and to integrate workers and employers.

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