Technical Communication

Indices of ergonomic-psycholsociological workplace quality in the greenhouses of Almería (Spain): Crops of cucumbers, peppers, aubergines and melons

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A B S T R A C T

This work uses the Labour Economics and Sociology Laboratory of France (LEST) method to evaluate the ergonomic-psycholsociological quality of work in horticultural greenhouse exploitations in Almería (Spain) with the aim of improving workers' occupational health. Data on the factors affecting the physical environment, the physical workload, mental workload, psychosocial aspects and the working hours of labourers were collected in 110 greenhouses, 35 of the Almeria *parral-plano* type and 75 of the *raspa y amagado* type. The crops raised in these greenhouses were cucumbers (24 greenhouses), peppers (25), aubergines (28), and melons (38). These greenhouses, typical of southeastern Spain, were found not to guarantee workers a comfortable working environment. The type of greenhouse and the crop raised within directly affected the ergonomic-psychosocial conditions of the workers. Suggestions are offered that might improve these conditions.

1. Introduction

The defines ergonomics as ''the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance''. According to the Fundación Mapfre (1995), the disciplines of ergonomics include biometric, environmental, cognitive, preventive, conceptual, corrective and specific ergonomics. More recently, Sebastián (2008) classified the field's disciplines as physical, cognitive and organisational ergo-nomics, the last of these covering occupational psychosociology and occupational psychopathology.

Many general evaluation methods have been developed for use by the different ergonomic disciplines, including the method of the Labour Economics and Sociology Laboratory of France (LEST) (Guélaud et al., 1975), the Régie Nationale des Usines Renault method (RNUR) (RENAULT, 1976), the method of the Agence National pour l'Amelioration des Conditions de Travail (ANACT) (Piotet and Mabile, 1984), the FREMAP mixed method (Fundación MAPFRE, 1995), the FAGOR method (1987), and the Ergonomic Workplace Analysis (EWA) method (FIOH, 1989). However, more discipline-specific methods are sometimes required, such as the Humidex Index (Masterton and Richardson, 1979), the wet bulb globe temperature index (WBGT) for thermal stress (Yaglou and Minard, 1957), the Rapad Upper Limb Assessment (RULA) (Mcatamney and Corlett, 1993) and Occupational Repetitive Action (OCRA) methods for repetitive movements (Colombini, 1998), the Ovako Working Analysis System (OWAS) for forced postures (Karhu et al., 1977), the National Institute for Occupational Safety and Health (NIOSH) method for the manipulation of loads (NIOSH, 1981), and the Mini Psychosocial Factors (MPF) method for psychosocial risks (Ruíz and Idoate, 2005).

Almost all of these methods have not been developed for agricultural workers of the greenhouses. In addition, their applications require the adaptation of theoretical method to the particular conditions of greenhouses of southeastern Spain.

Gustafsson and Lundqvist (1982) investigated human labour in the horticultural greenhouse setting, the conditions under which it was performed, the physical and mental health of workers, and the development of professional capacity. Other authors have examined the health and occupational safety of agricultural and horticultural workers, warning of the physical, physiological, chemical, biological, psychological and sociological risks they face (Lundqvist, 2000). These risks have also been studied from the point of view of workers' age (Nilsson et al., 2010). Other authors have investigated more quantitative risks. For example, Callejón-Ferre et al. (2011) studied thermal stress in greenhouse workers in southeastern Spain via the use of the Humidex Index, helping to improve the organisational ergonomics of agricultural companies. Also, Pérez-Alonso et al.(2011) have studied the occupational risks in the greenhouse con-struction companies, and they have found some problems or defi-ciencies in the prevention. All the above authors concur in that

greenhouse workers are surrounded by potential risks to their health.

There are nearly 30,000 agricultural greenhouses in Almeria, together providing work to some 45,000 people. The crops raised include tomato, aubergine, courgette, cucumber, pepper, water melon, melon and beans, although very few are now devoted to this last crop (Castilla, 2005). Using the LEST method of Guélaud et al. (1975), Callejón-Ferre et al. (2009) recently characterised the ergonomic–psychosocial quality of agricultural greenhouse exploitations devoted to the raising of tomato, courgette and water melon in southeastern Spain.

The aim of the present work was using the LEST method to determine the ergonomic-psychosocial quality of work in similar greenhouses devoted to raising pepper, melon, aubergine and cucumber, with the aim of improving the work conditions of the farmers.

2. Materials and methods

This study was performed at a number of intensive horticultural greenhouses (plastic covered) in the Province of Almería, Spain (Fig. 1).

The labourers employed by these exploitations spend 80% of their time inside the greenhouse (Fig. 2), either sowing, transplanting, propping up or pruning plants, applying fertilizer or pesticides, or harvesting etc. (García and Padilla, 2005).

The LEST method (Guélaud et al., 1975) was used to perform an ergonomic psycho-social assessment of the factors negatively affecting the physical environment, the physical workload, the psychosocial aspects and the working hours of labourers employed in this setting. This method was selected for the present purpose according to the assessment criteria of Stanton and Young (1998). The data required by the LEST method were recorded in 110 greenhouses (occupying a total area of 65.25 ha) between 8:00 and 12:00 h, from 16/02/2010 to 15/06/2010. These greenhouses, of which there were two types – the *raspa and amagado* type and *parral-plano* type – were devoted to raising cucumber (*Cucumis sativus* L.), pepper (*Capsicum annuum* L.), aubergine (*Solanum melongena* L.) and melon (*Cucumis melo* L.) (Fig. 2).

The LEST method allows an objective description to be made of the working conditions in greenhouses, providing an overall assessment that can be used as a basis for making improvements. This test, which is designed in such a way that all workers at an installation can participate in all stages of assessment, requires no specific knowledge before it can be used (Fundación Mapfre, 1995). It is arguably an ideal method for studying physical and mental workloads and metabolic expenditures, although it is not so appropriate for the analysis of the potential risks of injuries caused by cumulative traumatic disorders (Fundación Mapfre, 1995).

Fig. 1. Location of the studied greenhouses.

Data were collected through personal interviews with workers and/or exploitation owners, as well as with technical staff who acted as consultants regarding the test setting. Sixteen variables were measured, clustered into five relevant areas (Guélaud et al., 1975):

(a) Physical environment: thermal environment, lighting, noise and vibrations.
(b) Physical workload: static and dynamic.
(c) Mental workload: time pressure, complexity–speed, attention, and thoroughness.
(d) Psychosocial aspects: Initiative, social status, communication, cooperation, and identification with the product.
(e) Working hours.

All variables were measured on a scale of 0–10 (see Table 1).

Data were also collected to define the working environment, including the crop raised, the type of greenhouse and type of irrigation used etc. Light levels were measured using a Mavolux 5032C-USB luxometer (Gossen, Germany). A Questemp^0 36 model environmental thermal monitor was used to measure temperature. An HVM-100 vibrometer and sonometer (Larson Davis, USA) was used to measure vibrations and sound levels, a measuring tape was used to measure heights, and a chronometer to measure time. An index was then assigned to each variable, as described in the LEST method, and all data were subjected to ANOVA and the signif-icant minimal differences test.

3. Results

Of the 110 greenhouses for which data were collected, 35 were of the *parral-plano* type (occupying a total of 20.76 ha) and 75 of the *raspa y amagado* type (occupying a total of 44.49 ha) (Fig. 2). Each occupied an area of 0.2–1.0 ha. The crops raised in these greenhouses were cucumbers (24 greenhouses; 15.90 ha), peppers (25; 15.20 ha), aubergines (28; 14.75 ha), and melons (38; 19.40 ha).

The *X* axis of the graph in Fig. 3 represents the 16 variables measured, and the *Y* axis the indices returned according to the LEST method. Some factors (cooperation, dynamic load, social status, identification with the product, working hours and thermal environment) exceed the value of six (black line), showing that working in these greenhouses is not completely comfortable. In terms of cluster area, the physical environment, psychosocial aspects, physical load and working hours appeared as negative ergonomic factors.

Table 2 shows the differences in the ergonomic-psychosocial indices recorded depending on the type of greenhouse and crop raised. The indices for the variables working hours, identification with the product, thoroughness, attention, sound environment, vibrations and dynamic load were the same in all the greenhouses studied, irrespective of the type of crop raised; for this reason they do not appear in Table 2.

No significant differences were seen in the remaining data between the two types of greenhouse. When the same data were analysed with respect to the crop raised but irrespective of greenhouse type, significant differences were seen for the indices for thermal environment, time pressure, and complexity-speed. Under these comparison conditions, the least favourable crop in terms of thermal environment was melon (9.58). Complexity-speed was a source of problems in the cultivation of aubergine (6.75), pepper

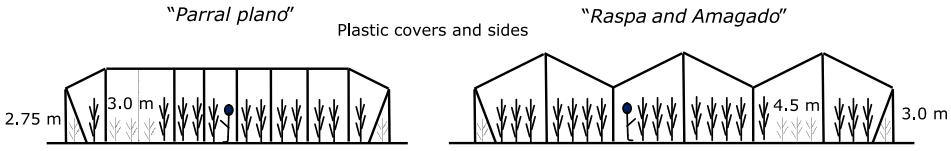

Fig. 2. Typical sections of the two types of greenhouse examined.

Table 1
LEST method index values and their interpretation (Guélaud et al., 1975).

Value	Effects
0, 1 and 2	Situation satisfactory
3, 4 and 5	Weak inconvenience. Improvements possible
6 and 7	Medium nuisance. Risk of fatigue (see red line and black line in Fig. 3)
8 and 9	Strong nuisance. Fatigue
10	Harmful

(6.16) and perhaps cucumber (5.54); in contrast, melon presented no problems in this respect (1.24).

Significant differences were seen between the values of all variables (except for the possibility of communication) for the different combinations of greenhouse type and crop. With respect to thermal environment, the least favourable combination was melon/*parral-plano*, with an index of 10.00. The combination cucumber/*parral-plano* was the most favourable, although still with an index of 7.00. The combination cucumber/*parral-plano* returned the worst static load index (6.25), while the best was returned by aubergine/*parral-plano* (5.56). With respect to complexity-speed, the combination aubergine/*raspa-amagado* showed the poorest index (7.00) while the most favourable was melon/*raspa-amagado* (1.00). The combinations melon/*parral-plano* and cucumber/*parral-plano* together returned the poorest social status indices (7.00), while aubergine/*parral-plano* retuned the best (6.56). Finally, the combination cucumber/*raspa-amagado* retuned the least favourable index with respect to cooperation (9.00), while the best was that seen for pepper/*raspa-amagado* (6.28).

4. Discussion

In general, these crop-growing greenhouses do not appear to allow workers to undertake their labours in a completely comfortable fashion (Fig. 3). The values recorded for the variables working hours, identification with the product, thoroughness attention, sound environment, vibrations and dynamic loads were always the same, showing that the LEST method might need to be adapted to detect possible variations, as indicated earlier by Call-ejón-Ferre et al. (2009). Other, more specific methods such as the MPF (Ruíz and Idoate, 2005), OCRA (Colombini, 1998) or Humidex Index (Masterton and Richardson, 1979) might also be used.

The results for the area of mental load (Fig. 3) highlight the simplicity of agricultural labour, as described by García and Padilla (2005), although the variable complexity–speed presents some problems with respect to the cultivation of aubergine, pepper, and cucumber (Table 2). Complexity-speed, however, presents no

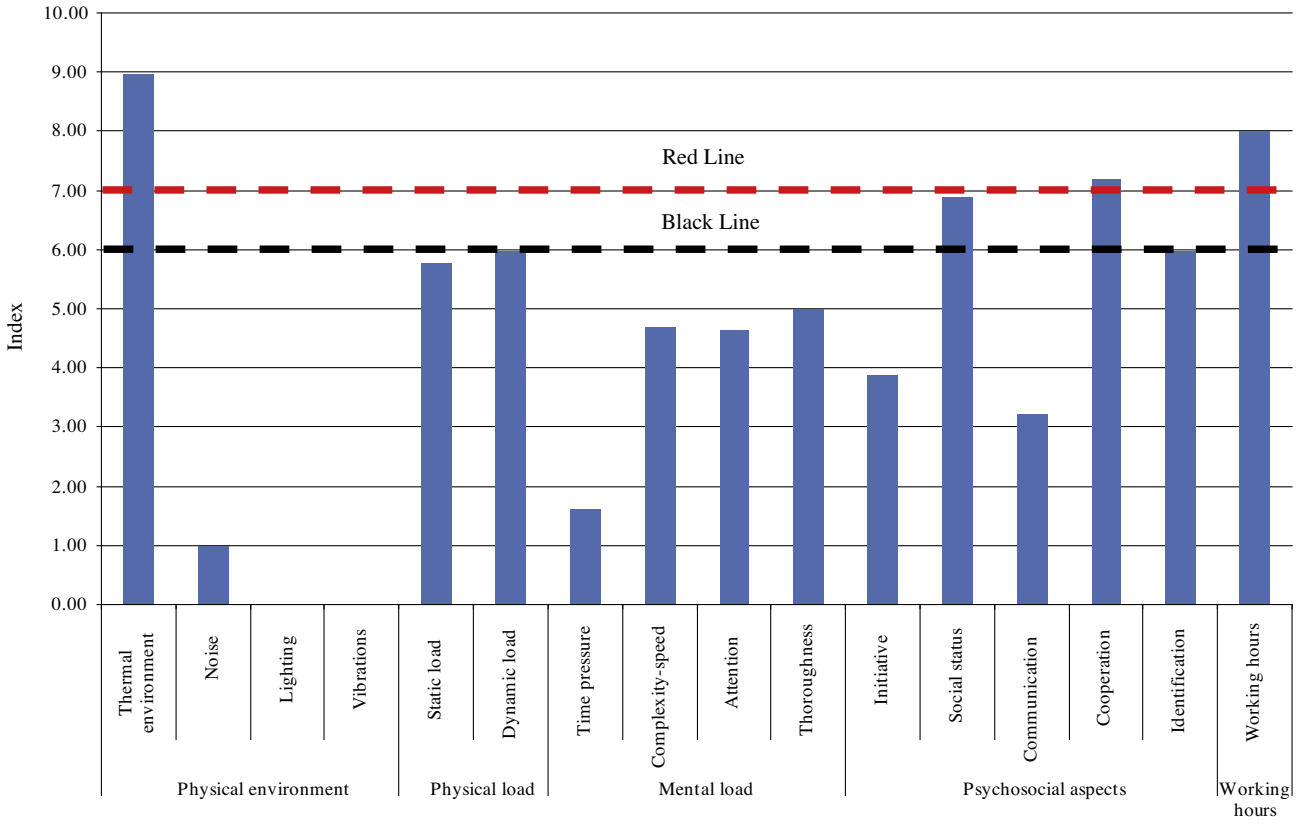

Fig. 3. Indices of the different variables monitored.

Table 2
Variation in ergonomic-psychosocial indices depending on the type of greenhouse and crop raised.

	Thermal environment	Static load	Time pressure	Complexity–Speed	Initiative	Social status	Communication	Cooperation
Greenhouse type								
Parral-plano	8.76a	6.00a	1.59a	5.40a	3.90a	6.83a	3.31a	7.30a
Raspa and amagado	9.09a	5.67a	1.65a	4.37a	3.87a	6.91a	3.20a	7.18a
Significance	ns	ns	ns	ns	ns	ns	ns	ns
Crops								
Melon	9.58b	5.52a	2.00b	1.24a	3.93a	6.94a	3.21a	7.41a
Aubergine	8.54a	5.86a	1.34a	6.75b	3.81a	6.82a	3.07a	7.25a
Pepper	8.78ab	6.04a	1.64ab	6.16b	3.83a	6.80a	3.28a	6.90a
Cucumber	8.92ab	5.75a	1.44a	5.54b	3.95a	6.96a	3.42a	7.25a
Significance	*	ns	*	*	ns	ns	ns	ns
Crops and greenhouse type								
Melon/*parral-plano*	10.00c	6.00ab	1.83bc	2.33a	4.22b	7.00c	3.00a	7.25ab
Aubergine/*parral-plano*	9.17bc	5.56ab	1.33ab	6.22b	3.89a	6.56a	3.11a	6.67a
Cucumber/*parral-plano*	7.00a	6.25b	0.88a	5.25b	3.85a	7.00c	3.50a	9.00b
Pepper/*parral-plano*	8.31ab	6.19b	1.81bc	6.13b	3.79a	6.88bc	3.50a	7.25ab
Melon/*raspa-amagado*	9.37c	5.41a	2.04c	1.00a	3.87a	6.93c	3.26a	7.44ab
Aubergine/*raspa-amagado*	8.24ab	6.00ab	1.34ab	7.00b	3.77a	6.95c	3.05a	7.53ab
Cucumber/*raspa-amagado*	9.30c	5.65ab	1.55ab	5.60b	3.97ab	6.95c	3.40a	6.90a
Pepper/*raspa-amagado*	9.61c	5.78ab	1.33ab	6.22b	3.89a	6.67ab	2.89a	6.28a
Significance	*	*	*	*	*	*	ns	*

ns and *; not significant and significant at $p \leqslant 0.05$ respectively (test for minimum significant differences).

problems in the cultivation of melon. Melon plants are creepers and give only one harvest; in addition, sowing, transplanting, training and pruning the plants is easier than with other crops. Further, the harvesting of certain other crops has to be undertaken very carefully, the fruits requiring protection from physical damage during collection; this might explain the score of 6.75 returned for complexity-speed with aubergine. The need to provide protection from physical damage to aubergines, cucumbers and peppers means these crops place greater demands on workers, some of which may be beyond their coping capacity, thus introducing potential psychosocial risks.

Although the indices returned for the variables thermal environment, static load, social status and cooperation indicate some risk, the type of greenhouse appeared to have no significant influence on its size (Table 2).

The indices for time pressure (1–2) were associated with no risk, despite the significant differences sometimes seen. The same was true for the variables initiative and possibility of communication (Table 2).

The thermal environment was a source of potential risk with all crops, especially with melon. Melon plants require a higher temperature and humidity in order for fruit to set. The values recorded for the present crops, although higher, followed the same trends with respect to botanical family as recorded in previous work (Callejón-Ferre et al., 2009), with spring cucurbitaceas (melon and water melon) associated with greatest risk.

Finally, the variables social status and cooperation were associated with risk in all crops and both types of greenhouse.

The values returned for the variables when greenhouse type and crop were combined were quite similar to those obtained when scores were recorded separately, with thermal environment, static load, social status and cooperation appearing as sources of risk in many cases (see Table 2). The worst thermal environment index was that obtained for the combination melon/*parral-plano*. As mentioned above, melon needs higher temperatures and a higher relative humidity for fruit to set, and cold must be avoided during transplanting at the end of the winter. This requires heat losses from the greenhouse be avoided.

The scores for static load approached risk levels for nearly all combinations, the highest risk being associated with the combination cucumber/*parral-plano*. Indeed, combinations involving the *plano parral* greenhouse nearly always presented the highest risk. This is clearly due to the lesser ventilation in *parral-plano* greenhouses compared to the *raspa y amagado* type. In addition, both melon/*parral-plano* and melon/*raspa y amagado* combinations were associated with the poorest social status and cooperation indices; this is almost certainly related to the thermal environment (Table 2). Finally, melon/*parral-plano* and melon/*raspa y amagado* were not associated with any risk in terms of time pressure or complexity-speed, initiative or the possibility of communication (Table 1), despite the significant differences recorded (Table 2).

Since the temperature measurements were taken in spring between the hours of 8:00 and 12:00 h (local time), and in Almeria a high temperature is reached after 10.00 h, the LEST scores for thermal environment were high (Callejón-Ferre et al., 2011). Work should therefore be organised differently at different times of year to avoid high thermal environment indices. For example, at the end of autumn and in winter, workers might be able to spend a full eight hours in these greenhouses, whereas in spring-summer shifts of 3–4 h might be acceptable. If work were organised in this way, the indices for working hours, cooperation and the possibility of communication might also improve (Callejón-Ferre et al., 2011).

The problematic variables mentioned above, as well as potentially problematic physical workload and psychosocial variables, could be improved by specific training for workers and employers (both separately and in combination).

In conclusion, these types of greenhouse, so typical of south-eastern Spain, do not guarantee workers a completely comfortable work environment; work needs to be appropriately organised. More specific methods might be useful for the study of the risk factors detected by the more general LEST method. Finally, further training of workers and employers is needed to improve risk problems, along with measures that bring them closer together in order to attain this goal.

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