

## Letter to the Editor

**The Relationship between Working Conditions and Adverse Health Symptoms of Employee in Solar Greenhouse\***ZHANG Min<sup>1</sup>, WANG Xiu Feng<sup>2</sup>, CUI Xiu Min<sup>1, #</sup>, WANG Jian<sup>1</sup>, and YU Shi Xin<sup>1</sup>

To determine the correlation between the working environment and the health status of employees in solar greenhouse, 1171 employees were surveyed. The results show the 'Greenhouse diseases' are affected by many factors. Among general uncomfords, the morbidity of the bone and joint damage is the highest and closely related to labor time and age. Planting summer squash and wax gourd more easily cause skin pruritus. Asthma-related cough, eye disease, and skin pruritus are significantly correlated with the cultivation of wax gourd. The application of inorganic fertilizer and fertigation dramatically induce the bone and joint damage. The smell of covering film greatly influence skin pruritus. Personal protection is badly scanty and normative occupational health and safety need to be completed.

Solar greenhouses are the main facilities for winter vegetable production in the northern area of China. However the workspace is closed, narrow, high temperature, and humidity. Greenhouses also produce deleterious substances that are difficult to remove promptly during the productive process. As the aging of greenhouse employees, such symptoms as bone and joint pain, skin pruritus, asthma-related cough, sneezing and gastritis occur, usually called 'Greenhouse diseases'<sup>[1-3]</sup>. This study aims to investigate the working conditions related to those discomforts and determine which factors contribute to the morbidity.

1171 employees from 97 natural villages were interviewed. All participants are over 25 years old, with over one year of vegetable planting experience in greenhouse. By the investigation method of 'door to door', both suggested-answers and open-ended questions were involved. The employee's conditions include age, gender, medical history, and educational level etc. Pathological signs include asthma-related cough, eye discomfort, skin pruritus, bone, and joint

pain and gastritis etc. In addition, working time, vegetable species, fertilizer types and the sources of peculiar smells in greenhouse are also surveyed. The data were analyzed by SPSS software 16.0.

Of 1171 questionnaires, 74 people were excluded for medical histories. Among the remaining 1097 respondents, 650 farmers including 368 men and 282 women suffered from 'Greenhouse diseases'. The morbidity of bone and joint pain (like neck and low back pain) is 49.95%. The morbidities of eye discomfort, skin pruritus, gastritis, nasal discomfort and asthma-related cough are 8.02%, 7.38%, 7.11%, 6.56%, and 5.56% respectively. The morbidity of asthma-related cough among employees with a history of smoking is higher than that of those never smoking.

Table 1 illustrates that the morbidity differences of bone and joint pain in each age group are obvious among different working years. With the increase of working years, the morbidity of bone and joint pain tends to rise. For the employees over age 55, 4-6 year of working experience is the keypoint of the morbidity of bone and joint pain ( $\chi^2=9.75$ ,  $P<0.05$ ). The employees age 45-54 with over 10 years of working experience show the highest morbidity (84.62%). The morbidity of employees age 35-44 peak at 64.52% when working for 7-9 years.

Seen from Table 2, the longer working hours, the more likely to suffer from bone and joint pain, the morbidity of which among employees working 8 hours or more reached 55.89%. 8 h working time is a turning point of joint pain ( $\chi^2=7.09$ ,  $P<0.05$ ). The influence of working hours on asthma-related cough, eyes discomfort, nasal discomfort, and skin pruritus is very little. The type of fertilizer is significantly correlated with specific symptoms ( $\chi^2=17.23$ ,  $P<0.05$ ). The influence of inorganic fertilizer is the largest to 'Greenhouse diseases' except nasal discomfort, which is related mostly to organic fertilizer. The morbidity related to biological fertilizer and

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controlled-release fertilizer is lower than that of other fertilizers. Different fertilizing ways are significantly correlated with each symptom ( $\chi^2=29.09$ ,  $P<0.05$ ). Fertigation is the most adverse way on bone and joint pain (60.77%). Spraying way most affect the morbidity of asthma-related cough, skin pruritus. Broadcasting way has a higher impact on morbidity of eye and nasal discomfort. Compared with other fertilization way, spotting is the safest. The morbidity differences due to different species of greenhouse

Table 1. Morbidity of Bone and Joint Pain Among Employees by Age and Working Years

Working Years	Age Range (y)							
	25-34		35-44		45-54		≥55	
	<i>n</i>	Positive No. (Positive rate, %)	<i>n</i>	Positive No. (Positive rate, %)	<i>n</i>	Positive No. (Positive rate, %)	<i>n</i>	Positive No. (Positive rate, %)
1-3	24	6 (25.00)	30	7 (23.33)	27	10 (37.04)	22	5 (22.72)
4-6	17	2 (11.76)	65	24 (36.92)	85	30 (35.29)	254	142 (55.91)
7-9	18	8 (44.44)	31	20 (64.52)	62	29 (46.77)	327	185 (56.57)
≥10	3	0 (0)	17	8 (47.06)	13	11 (84.62)	176	108 (61.36)

Table 2. Morbidity of Selected Symptoms Among Employees in Different Situation

Deferent Situation	Bone and Joint Pain (%)	Asthma-related Cough (%)	Eyes Discomfort (%)	Nasal Discomfort (%)	Skin Pruritus (%)	Gastric Discomfort (%)
Working hours						
<4	48.48	5.45	9.09	1.82	5.45	-
4-7	47.77	5.39	8.40	6.50	6.81	-
≥8	55.89	7.30	7.30	7.30	8.52	-
Types of fertilizers						
Inorganic fertilizer	40.15	11.41	18.11	9.45	14.17	13.39
Organic fertilizer	9.94	9.29	7.69	14.74	7.37	8.33
Biological fertilizer	9.28	4.22	5.91	4.22	6.33	7.59
Controlled-release fertilizer	1.70	4.08	4.08	4.08	8.16	0
Fertilization way						
Broadcasting	1.82	4.90	16.08	11.19	9.79	9.87
Spotting	1.64	5.80	3.62	5.07	3.71	2.1
Spraying	24.27	15.79	10.53	5.26	21.05	9.52
Fertigation	60.77	6.98	8.04	6.22	6.37	7.50
Cultivated crops						
Tomato	-	10.49	8.39	9.79	6.99	2.10
Cucumber	-	7.10	10.32	8.39	7.10	1.29
Pepper	-	2.48	9.09	2.48	6.61	0.83
Summer squash	-	1.90	8.57	2.86	19.05	0
Tower gourd	-	2.65	2.65	0.66	3.31	1.32
Wax gourd	-	18.89	17.48	4.90	23.78	0.70
Watermelon	-	7.33	3.67	3.67	0	0.92
Kidney bean	-	0	0	0	19.63	0
Source of odor						
Fertilizer	-	9.48	13.79	11.21	11.21	4.43
Pesticide	-	11.21	13.79	13.79	9.48	10.51
Covering film	-	0	0	8.33	33.33	0
Vegetable	-	12.40	5.43	12.40	9.33	2.84

**Note.** ‘-’ stand for the mutual relations between symptoms and situation is unknown.

plants on each symptom are significant ( $\chi^2=61.43$ ,  $P<0.05$ ). The employees planting wax gourd have higher morbidity of asthma-related cough, eye discomfort and skin pruritus. Those planting summer squash, wax gourd and kidney bean are more likely to suffer from skin pruritus. The morbidity of all symptoms are low among the employees planting watermelon and towel gourd. The difference between the odors and the morbidity of all symptoms is significant ( $\chi^2=7.14$ ,  $P<0.05$ ). The smell of fertilizers is significantly correlated to eye discomfort morbidity (up to 13.79%). The smell of pesticides has more significant effects on asthma-related cough, eyes, nose, and skin discomforts. The smell of covering film most correlated with skin pruritus ( $\chi^2=5.32$ ,  $P<0.05$ ). The smell of vegetables dramatically correlates with asthma-related cough and nasal discomfort ( $\chi^2=10.31$ ,  $P<0.05$ ).

Table 3 showed that the morbidity of eye discomfort, nasal discomfort, skin pruritus and gastric discomfort among employees using PPE is higher than those lacking PPE. This is likely due to improperly protective measures. However the higher educational levels, the stronger protection awareness.

The average morbidity of ‘greenhouse diseases’ reach 59.25%, among which the bone and joint pain disease is most remarkable. With an extension of working periods and the daily operating time in greenhouse, this morbidity tends to rise, which ultimately relates to the microclimate around. Obviously the operational space in greenhouse is air-tight, narrow, and small. With the opening and closing of ventilating device, temperatures and humidity rise and fall dramatically, which is a vital factor to bone and joint pain<sup>[4]</sup>. Besides, seedling, weeding, fertilizing, spraying germicide, and harvesting, all the repetitive motions easily result in discomforts in upper limb, shoulder, and neck.

Inorganic fertilizers are highly correlated with bone and joint pain morbidity (up to 40.15%). This

may be because of chemical substances from fertilizer penetrating into bones and joints and accumulating to a certain level. Studies have shown when urea, diammonium phosphate and farmyard manure are applied to greenhouse soil as a base fertilizer,  $\text{NH}_3$  or  $\text{NH}_4^+$  is produced during the decomposition or fermentation process. The concentration of  $\text{NH}_3$  will increase gradually in soil. As the soil pH rises, ammonia volatilizes. Sun radiation and higher temperature make ammonia volatilize faster, and  $\text{NH}_3$  in air increases accordingly. This is a serious effect on eye mucous and the respiratory tract<sup>[5]</sup>. Organic fertilizers can release a large amount of heat and  $\text{SO}_2$  during fermentation. Together with non-living stimuli like sweat, pollen and dust can lead to acute conjunctivitis, inflammation of the eye edge, asthma, and cough.  $\text{NH}_3$  can also be swallowed into the digestive tract and cause gastric mucosa damage, thus leading to chronic inflammation. Controlled-release fertilizers significantly impact skin pruritus. This may be correlated to the coated materials. Biological fertilizers has no adverse effect on employee health. It is reported that these fertilizers not only reduce denitrification but also help the accumulation of antibiotics produced by microorganisms, which inhibit the growth of pathogenic bacteria in rhizosphere<sup>[6]</sup>.

Fertilizing methods affect the incidence of various diseases. During spraying, fertilizers instantaneously float in the air in form of fogdrop. However, the greenhouse air flow slowly, and the respiratory rate of employees is higher, which make it easier to inhale more fertilizer than normal. Broadcasting fertilizer significantly influences morbidity related to the eyes and nose. A possible reason for this is that the nitrogenous fertilizers decomposes rapidly and releases ammonia gas when meeting water on the surface of soil. Owing to spatial closure and high temperature, fertigation makes excessive moisture disperse in the air and difficult to discharge promptly, so this fertilizing way

**Table 3.** Morbidity of Selected Symptoms Among Employees in Different Personal Protective Equipment (PPE)

PPE	Prevalence					The Percentage of Individuals				
	Asthma-related cough	Eyes discomfort	Nasal discomfort	Skin pruritus	Gastric discomfort	Illiteracy	Elementary school	Junior high school	High school	College or above
Use	6.25	8.46	8.82	7.54	4.04	27.57	26.84	31.07	31.80	62.50
Lack	6.75	7.82	5.68	7.28	3.37	72.30	73.20	68.92	68.21	37.48

easily induces bone and joint pain. Besides, temperature difference between inside and outside greenhouse easily results in joint pain<sup>[3]</sup>. However, fertigation can reduce the loss of low-ammonia nitrogen and the emission of nitrous oxide. The application of nitrogenous fertilizers by spotting and watering after fertilization can reduce the occurrence of 'greenhouse diseases', and that enhance the utilization rate of fertilizers<sup>[7]</sup>.

Farmers planting tomatoes have a higher morbidity of asthma-related cough and nasal discomfort. This is perhaps due to the special type of fungal infection diseases (leaf mold) involved during the growing process. In addition, the stem and leaf of tomato could give off a distinct pungent smell. Both of which can cause strong reaction in respiratory tract<sup>[1]</sup>. Farmers growing wax gourd have significantly higher morbidity of asthma-related cough, eye discomfort and skin pruritus, possibly because wax gourd is susceptible to powdery mildew as well microbial growth in warm and humid environments. The smell of rotted wax gourd and the tiny spores are hazardous to the respiratory tract, eyes and skin, and similar cases occur in summer squash and kidney bean. Employees are likely allergic to the tomentum on the surface of these crops. The farmers growing cucumber, sweet pepper and towel gourd have lower morbidity of asthma, consistent with Teng's findings<sup>[8]</sup>.

Higher education makes access to health knowledge easier and self-protection awareness stronger. But it's worth noting that employees using PPE have higher morbidity of eye, nose, and skin pruritus than those lacking PPE. Seemingly this is caused by simple or improper PPE. Essentially, lack of professional guidance and technical training is the most crucial factor. Many employees are unsure what measures are suitable for fertilizing and applying pesticide. In this investigation vegetable growers wear gloves, but few wear masks, hats or protective glasses. There is a principal consideration that using protective equipments (like gloves, masks etc.) is not only troublesome but also costly. When working in greenhouse, they often randomly remove protective items to wipe eyes or rub nose with hands, such behaviors undoubtedly unhealthy. Especially hands are easily contaminated by bacteria pathogenic to plants as well as sprayed pesticides. Research shows 73.19% of peasant employees with occupational diseases don't understand the hazards of their occupations, 46.40% of these employees don't know how to take protective measures for work.

The peculiar smell of vegetables accounts for the largest percentage of odor sources, followed by fertilizers and pesticides. The odor of vegetables has a significant impact on the incidence of asthma-related cough and nasal discomfort. According to a survey of Japanese cucumber growers in plastic greenhouses, respiratory and skin allergy symptoms were prevalent<sup>[1]</sup>. Other suspended particles like dust, mites or spider also lead to strong sensitization or respiratory discomfort<sup>[9]</sup>. Fertilizers (like ammonia and ammonium bicarbonate) give off irritant odor that intensively causes the diseases of asthma-related cough, the eyes, nose, and skin. 51.6% percent of farmers spray pesticide every other 5-7 d. With appropriate protection, the emulsion and aerosol can easily enter the respiratory tract. Studies show if a bulk spray approach is used for greenhouse crops, 2% of the pesticide residues settles on the bodies. Besides the intensifying breath during the working process also make more particles with pesticide be inhaled. Particles less than 7  $\mu\text{m}$  in size can directly reach to the lung cavity, which are the vital factors inducing 'Greenhouse Diseases'<sup>[8]</sup>. The smell of covering film obviously impact the rhinopathy and skin pruritus, which are likely because the unqualified film release such harmful materials as chlorine, diisobutyl, BDP, or DEHP<sup>[10]</sup>.

'Greenhouse diseases' are influenced by various factors in greenhouse, and it's a result of comprehensive interaction. Indoor microclimate, working hours, improper fertilization, pesticide usage, and unprofessional protection etc are likely the direct crucial factors inducing 'Greenhouse diseases'. Therefore more attentions should be given to the above-mentioned aspects.

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