



Green Tobacco Sickness among Thai Traditional Tobacco Farmers, Thailand

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Abstract

Background: Traditional Thai tobacco (*Nicotiana abacus* L.) is known as a non-Virginia type whose mature leaf contains three to four times more nicotine than that of a Virginia type. As such, the process of Thai traditional tobacco production may lead to adverse health effects such as green tobacco sickness (GTS).

Objective: To investigate the prevalence of GTS and risk factors related to GTS among Thai traditional tobacco farmers in Nan province, northern Thailand.

Methods: 473 Thai traditional tobacco farmers from rural areas in Nan province were randomly selected and interviewed in person by means of questionnaires and environmental survey. Statistical analyses were used to identify potential risk factors for GTS.

Results: The prevalence of GTS was 22.6% (95% CI 19.1% to 26.6%). Multivariate analysis showed various risk factors associated with GTS including gender of the farmer (OR_{adj} 0.44, 95% CI 0.26 to 0.73), smoking (OR_{adj} 4.36, 95% CI 1.41 to 13.47), skin rash (OR_{adj} 0.36, 95% CI 0.19 to 0.68), wearing a wet suit (OR_{adj} 1.91, 95% CI 1.12 to 3.23), process of curing tobacco leaves (OR_{adj} 0.06, 95% CI 0.02 to 0.16), and watering tobacco plants (OR_{adj} 0.42, 95% CI 0.25 to 0.72).

Conclusion: The process of traditional Thai tobacco production can result in increased dermal exposure and can be considered a major risk factor for GTS. Body soaking during watering may further increase adverse health effects related to GTS.

Keywords: Prevalence; Risk factors; Tobacco; Thailand; Agricultural workers' diseases

Introduction

Nicotiana tabacum L. is grown in over 100 countries. The largest plantations are located in China, Brazil, India, the USA, and Malawi. These countries together account for two-thirds of the world's tobacco production.¹ Tobacco farming is associated with the hazard of green tobacco sickness (GTS). The disease originates from nicotine's ability to penetrate through the skin of workers

who cultivate and harvest tobacco.¹⁻³ GTS is an occupational illness reported by tobacco workers worldwide.⁴⁻⁷ Previous studies have shown that dermal absorption of nicotine from plant surfaces gives rise to characteristic GTS symptoms.⁸⁻¹⁰ GTS morbidity concerns nearly a quarter of tobacco workers, with typical symptoms including nausea, vomiting, headache, abdominal cramps, breathing difficulty, abnormal body temperature, pallor, chills, fluctuations in blood pressure and heart

Cite this article as: Saleeon T, Siriwong W, Maldonado-Pérez HL, Robson MG. Green tobacco sickness among Thai traditional tobacco farmers, Thailand. *Int J Occup Environ Med* 2015;**6**:169-176.

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Received: Nov 22, 2014
Accepted: May 12, 2015

rate, drenching sweats, and increased salivation.¹⁻³ GTS is a result of acute nicotine poisoning caused by dermal absorption of nicotine from mature tobacco plants. GTS is mainly characterized by nausea or vomiting, headaches, and dizziness.^{11,12}

Nan province, northern Thailand, is one of the most famous areas well known for cultivation of traditional Thai tobacco plants. Traditional Thai tobacco (*Nicotiana tabacum* L.) is known as a non-Virginia type tobacco. Its mature leaves are thicker and contain 3–4 times more nicotine than the leaves of a Virginia type tobacco. From 2012 to 2013, the traditional tobacco cultivation areas increased by 50% due to favorable prices and an increase in profits, which encouraged farmers to cultivate more. The provincial total production of the tobacco plant was around 3.7 million kilograms from a total area of 2830 acres. The largest tobacco harvest was reported in 2013 from Thawangpha district, approximately 1.6 million kilograms; Chiangklang district, about 920 000 kilograms; and Pua

district, around 715 300 kilograms.

Traditional tobacco cultivation and dry tobacco production in Thailand differ from those found in western countries. Cultivation is a continuous process to maintain the tobacco plants, especially watering activities with which farmers may come into contact with wet tobacco leaves. Almost all farmers water their plants in the morning or in the evening. The process of Thai traditional tobacco production involves seeding, cultivating, and transplanting to the tobacco field; maintaining tobacco plants with fertilizer and pesticide applications; removing axillaries buds; cutting the top of tobacco plants; and removing weeds from the field. After 100 to 120 days, tobacco leaves can be picked and then transferred for subsequent processing. Tobacco leaves are cured until ripe; then the stems are removed by drawing and rolling tobacco leaves in a bundle so that it can be prepared for slicing by a cutting machine. The sliced tobacco leaves are brought to a bamboo rack, shredded, and left to dry in a dry rack in direct sunlight for 1–3 days. Every day and night, the farmers must reverse the bamboo rack so as to control the color of the tobacco line which can be adjusted by spraying a dry tobacco extract in the evening. The night-time dew will soften the tobacco slices and allow them to be folded for packaging, with 10 kg of tobacco slices per plastic bag. By processing Thai traditional tobacco, the farmers will be exposed to nicotine in tobacco leaves and may be at risks of health effects caused by GTS. As for Thailand, it is worth noting that a diagnostic criteria for GTS has not yet been established, and this could be a potential cause of GTS in Thai traditional tobacco farmers.

The objective of this study was to investigate the prevalence of GTS and characteristic factors related to GTS among Thai traditional tobacco farmers at Praputthabath sub-district, Chiangklang district,

TAKE-HOME MESSAGE

- Thai traditional tobacco cultivation is considered an occupation in the gray zone, meaning even though it is not prohibited, it is not promoted by the government sector.
- Green tobacco sickness (GTS) is an adverse health effect of nicotine poisoning that takes place 2–3 days after exposure to tobacco leaves. Typical symptoms include headache, nausea, vomiting, and dizziness.
- The prevalence of GTS in Thai traditional tobacco farmers was 22.6%, but the actual rate may even be higher than this because of under-reported cases.
- The process of Thai traditional tobacco processing can result in increased dermal exposure, a major risk factor for GTS.
- Body soaking during watering the plant may increase adverse health effects related to GTS.

and Phatow sub-district, Thawangpha district in Nan province, Thailand. It was anticipated that the findings of this study can be used to help expand surveillance and prevention of GTS as well as to explain GTS etiology for farmers so that improvement of these tobacco farmers' working conditions in this area could be made.

Materials and Methods

Sampling

Thai traditional tobacco is cultivated in Nan province, a region in northern Thailand composed of 15 districts. Almost all districts have been involved in the cultivation of traditional tobacco for 60 years. Five districts are devoted to tobacco cultivation with two of them—Thawangpha and Chiangklang districts—being large-scale areas. Seven villages and 1116 households in Phatow sub-district in Thawangpha district and 10 villages and 1755 households in the Praputthabath sub-district in Chiangklang district were chosen as the study population and study area. The household representatives were responsible for completing interviewer-administered questionnaires. The calculated minimum sample size was 473 from a total of 2871 male and female farmers working in the region between 20 and 65 years of age. The participants were recruited using a systematic random sampling from tobacco farmers in the area. Farmers who had generally good health and were growing tobacco, picking tobacco leaves, or producing dry tobacco regularly during the season were included in the study. Those who did not exhibit any particular symptoms from either tobacco sickness or from pesticide exposure were excluded from the study.

Measurements

A cross-sectional study was conducted with 473 Thai traditional tobacco farmers

in Praputtabath sub-district and Phatow sub-district. The farmers were randomly selected and interviewed in an in-person survey using a modified method described earlier.¹¹⁻¹³ The interview questionnaire was validated by a panel of three experts to ensure its content validity; its index of objective congruence (IOC) was 0.87. Thereafter, the questionnaire was tested with 30 subjects whose demographic characteristics were similar to those of the main study to determine reliability of the questionnaire; the Cronbach's α was 0.81. The survey consisted of questions about demographic characteristics (age, sex, family status, level of education, current smoking status, and alcohol consumption), work-related conditions (process of tobacco plant cultivation with seeding, growing, watering, fertilizing, and using pesticides), process of maintaining tobacco plants (watering, cutting top and axillaries buds, dropping herbicide on the top and buds, fertilizing, removing grass, and spraying insecticide), and picking and curing tobacco leaves (picking tobacco leaves, transporting leaves from farm to home, and curing tobacco leaves). The questionnaire also consisted of questions about GTS symptoms including subjective health symptoms that gave rise to acute nicotine poisoning caused by dermal absorption of nicotine from the mature tobacco plants. GTS symptoms included vomiting, nausea, headaches, and dizziness.¹¹ The in-person survey and environmental survey were undertaken in December 2012.

This study was approved by the Institutional Review Board of the College of Public Health Sciences, Chulalongkorn University (code COA No.170/2555).

Statistical Analysis

All data were coded and analyzed by SPSS[®] ver 17 for Windows[®]. Descriptive statistics and frequency of the studied variables were calculated and reported. The preva-

Table 1: Characteristics and prevalence of GTS in Thai traditional tobacco farmers (n=473)

| Characteristics | n (%) |
|--|------------|
| Gender | |
| Male | 240 (50.7) |
| Female | 233 (49.3) |
| Age group (yrs) | |
| 35–51 | 248 (52.4) |
| 52–65 | 225 (47.6) |
| Status in family | |
| Head of family | 268 (56.7) |
| Housewife | 195 (41.2) |
| Member | 10 (2.1) |
| Education level | |
| Primary school | 393 (83.1) |
| Secondary school | 75 (15.8) |
| Higher than secondary school | 5 (1.1) |
| Smoking | |
| No | 420 (88.8) |
| Yes | 53 (11.2) |
| Living with smokers | |
| No | 439 (92.8) |
| Yes | 34 (7.2) |
| Alcohol consumption | |
| No | 182 (38.5) |
| Yes | 291 (61.5) |
| Experience with tobacco plantation (yrs) | |
| <20 | 52 (11.0) |
| ≥20 | 421 (89.0) |
| Current work with tobacco (hrs/day) | |
| 0–5 | 199 (42.1) |
| 6–10 | 274 (57.9) |

lence of GTS was stratified by farmers' characteristics, work-related characteristics, and subjective health symptoms. χ^2 or Fisher's exact test were used to analyze the categorical variables. Multiple logistic regression analysis was used to determine the independent risk factors of GTS. Those variables that were associated with GTS at a level of 0.20 from univariate analyses were selected into the multiple logistic regression model. Likelihood ratio test (LRT) was used to test the variables associated with GTS by comparing models with and without referring variables. Wald test was used to test the significance of each level compared with the reference level on particular variables. A p value <0.05 was considered statistically significant.

Results

Demographic data of participants are presented in Table 1. The mean age of the participants was 51.8 (SD 7.4; range 35 to 65) years. More than half of the participants were head of their family; most of them completed the primary education. Almost all of the participants had been working on a traditional tobacco plantation for more than 20 years. The mean working hours with tobacco was 5.3 (range 0 to 10) hours per day. One hundred and seven out of 473 participants had GTS, hence a prevalence of 22.6% (95% CI 19.1% to 26.6%); the prevalence was 17.9% in males and 27.5% in females (Table 1). Table 2 shows the effect of various demographic variables on the prevalence of GTS in univariate analysis. Being male, smoker, alcohol drinker, and having experience more than 20 years, curing tobacco leaves, wearing wet suit, hand washing with acid soap, and cutting top of, axillary buds of, or watering tobacco plants were significantly associated with a higher prevalence of GTS (Table 2). Having skin rash was significantly associated with developing GTS (OR 2.80, 95%

CI 1.58 to 4.98).

Multiple logistic regression analysis revealed the independent risk factors of GTS after being adjusted for sex, smoking, skin integrity, wearing a wet suit, type of work with tobacco in a day including curing tobacco leaves and watering tobacco plants (Table 3).

Discussion

We found that GTS occurred in females more than one and half times than in males. Almost all farmers graduated from a primary school and farming was their traditional vocation. This is consistent with the fact that Thai traditional tobacco cultivation in this area is a part of local culture and folk life. It is worth noting that even though the health effects of tobacco cultivation were known to these farmers, they did not recognize the route of effects or the causes of known health problems. Such a finding yielded support to the finding of a previous study.² In addition, the results of this study showed that the total prevalence of GTS was 22.6%. This can be considered the first documentation of GTS prevalence among Thai traditional tobacco farmers in Nan province. There is a wide range of the reported prevalence of GTS in the literature—from 8% to 89% per season. The highest discrepancy in the reported prevalence rates would be attributed to nonuniform case definitions.¹⁴ Two studies found very high relative odds of GTS when farmers were working in wet conditions.^{13,15}

The prevalence of GTS was 17.9% in men and 27.5% in women. This finding was inconsistent with what has previously been reported in other studies where almost all of the farmers affected by GTS were male.¹⁶ In traditional tobacco cultivation in Thailand, female farmers share the role of intensive producers through their labor with their male counterparts.^{17,18} Similarly, there was no gender difference

Table 2: Association of GTS with various demographic and work-related characteristics among Thai traditional tobacco farmers (n=473)

| Factors | GTS, n (%) | | OR (95% CI) |
|---|------------|------------|---------------------|
| | Yes | No | |
| Gender | | | |
| Male | 43 (40.2) | 197 (53.8) | 1.73 (1.12 to 2.68) |
| Female | 64 (59.8) | 169 (46.2) | |
| Education level | | | |
| Primary school | 91 (85.0) | 302 (82.5) | 0.83 (0.45 to 1.50) |
| Secondary school and higher | 16 (18.1) | 64 (61.9) | |
| Smoking | | | |
| No | 101 (94.4) | 319 (87.2) | 0.40 (0.16 to 0.97) |
| Yes | 6 (5.6) | 47 (12.8) | |
| Living with smokers | | | |
| No | 97 (90.7) | 342 (93.4) | 0.14 (0.67 to 3.17) |
| Yes | 10 (9.3) | 24 (6.6) | |
| Alcohol consumption | | | |
| No | 63 (58.9) | 119 (32.5) | 0.33 (0.21 to 0.52) |
| Yes | 44 (41.1) | 247 (67.5) | |
| Experience with tobacco plantation (yrs) | | | |
| <20 | 5 (4.7) | 47 (18.2) | 3.00 (1.16 to 7.76) |
| ≥20 | 102 (95.3) | 319 (87.2) | |
| Current work with tobacco | | | |
| No | 0 (0) | 33 (9.0) | 1.32 (1.25 to 1.39) |
| Yes | 107 (99.5) | 333 (91.0) | |
| Cutting top of tobacco plants | | | |
| No | 77 (72.0) | 282 (77.0) | 1.30 (0.80 to 2.12) |
| Yes | 30 (28.0) | 84 (23.0) | |
| Cutting axillaries buds of tobacco plants | | | |
| No | 58 (54.2) | 241 (65.8) | 1.62 (1.05 to 2.52) |
| Yes | 49 (45.8) | 125 (34.2) | |
| Watering tobacco plants | | | |

Continued

Table 2: Association of GTS with various demographic and work-related characteristics among Thai traditional tobacco farmers (n=473)

| Factors | GTS, n (%) | | OR (95% CI) |
|------------------------------|------------|------------|---------------------|
| | Yes | No | |
| No | 62 (57.9) | 290 (79.2) | 2.77 (1.74 to 4.38) |
| Yes | 45 (42.1) | 76 (20.8) | |
| Curing tobacco leaves | | | |
| No | 83 (77.6) | 359 (98.1) | 2.77 (1.74 to 4.38) |
| Yes | 24 (22.4) | 7 (1.9) | |
| Wearing a long-sleeved shirt | | | |
| No | 18 (16.8) | 69 (18.9) | 1.14 (0.64 to 2.03) |
| Yes | 89 (83.2) | 297 (81.1) | |
| Wearing long pants | | | |
| No | 9 (8.4) | 43 (11.7) | 1.45 (0.68 to 3.07) |
| Yes | 98 (91.6) | 323 (88.3) | |
| Wearing a raincoat | | | |
| No | 73 (68.2) | 221 (60.4) | 0.71 (0.44 to 1.12) |
| Yes | 34 (31.8) | 145 (39.6) | |
| Wearing a plastic apron | | | |
| No | 72 (67.3) | 240 (65.6) | 0.92 (0.58 to 1.46) |
| Yes | 35 (32.7) | 126 (34.4) | |
| Wearing gloves | | | |
| No | 60 (56.1) | 214 (58.5) | 1.10 (0.71 to 1.70) |
| Yes | 47 (43.9) | 152 (41.5) | |
| Wearing boots | | | |
| No | 59 (55.1) | 202 (55.2) | 1.00 (0.65 to 1.54) |
| Yes | 48 (44.9) | 164 (44.8) | |
| Wearing wet suit | | | |
| No | 33 (30.8) | 147 (40.2) | 0.66 (0.41 to 1.05) |
| Yes | 74 (69.2) | 219 (59.8) | |
| Hand washing with acid soap | | | |
| No | 40 (37.4) | 95 (26.0) | 0.58 (0.37 to 0.92) |
| Yes | 67 (62.6) | 271 (74.0) | |

in the report of health problems of tobacco farmers in Vietnam.¹⁹

We found smoking was protective against developing GTS. Such findings were consistent with the differences in GTS in two groups of farmers reported by Gehlbach, *et al*,⁵ that farmers believed in the protective effects of tobacco use. In the current study, however, farmers did not see smoking as having a protective effect on GTS. Only 11% of the farmers were smokers.

Work activities that were associated with GTS included exposure to wet plants and mature tobacco plants, as well as cutting axillary buds, which put farmers at higher risk of exposure to nicotine. This is because farmers have to repeatedly carry out such activities every week. To further explain, to remove axillaries, farmers have to walk through and move up and down the rows of plants, hence exposure to nicotine bearing foliage. Moreover, farmers use their hands and arms when working, and they can easily come into contact with the sap and gum from the tobacco plants when transferring the leaves from the pick-up truck or pushcart to the place where tobacco leaves are cured. Also, watering the plants with a hose, sprinkler, or pipeline is associated with GTS through dermal exposure; GTS was also associated with changing work clothes. Wet clothing may increase exposure to nicotine from mature plants via dermal absorption. As found in other studies, use of personal protective equipment among farmers can significantly reduce GTS.²⁰ However, it is noteworthy that environmental tobacco smoke exposure through living with smokers (passive smoking) does not have a significant effect on GTS. Another issue that should be mentioned here is that many studies so far conducted on GTS have not attempted to establish the criteria for the diagnosis of GTS. Therefore, any direct assessment and diagnosis of GTS or using

Table 3: Multiple logistic regression analysis of risk factors of GTS among Thai traditional tobacco farmers (n=473)

| Factors | GTS, n (%) | | OR (95% CI) | OR _{adj} (95% CI) |
|-------------------------|------------|------------|---------------------|----------------------------|
| | Yes | No | | |
| Gender | | | | |
| Male | 43 (40.2) | 197 (53.8) | 1.73 (1.12 to 2.68) | 0.44 (0.26 to 0.73) |
| Female | 64 (59.8) | 169 (46.2) | | |
| Smoking | | | | |
| No | 101 (94.4) | 319 (87.2) | 0.40 (0.16 to 0.97) | 4.36 (1.41 to 13.47) |
| Yes | 6 (5.6) | 47 (12.8) | | |
| Skin rash | | | | |
| No | 16 (15.0) | 121 (33.1) | 2.80 (1.58 to 4.98) | 0.36 (0.19 to 0.68) |
| Yes | 91 (85.0) | 245 (66.9) | | |
| Watering tobacco plants | | | | |
| No | 62 (57.9) | 290 (79.2) | 2.77 (1.74 to 4.38) | 0.42 (0.25 to 0.72) |
| Yes | 45 (42.1) | 76 (20.8) | | |
| Curing tobacco leaves | | | | |
| No | 83 (77.6) | 359 (98.1) | 2.77 (1.74 to 4.38) | 0.06 (0.02 to 0.16) |
| Yes | 24 (22.4) | 7 (1.9) | | |
| Wearing a wet suit | | | | |
| No | 33 (30.8) | 147 (40.2) | 0.66 (0.41 to 1.05) | 1.91 (1.12 to 3.23) |
| Yes | 74 (69.2) | 219 (59.8) | | |

a biomarker for GTS, should be validated first. The measurements used in previous studies were correlated with cotinine levels.^{10,11} Finally, a validated questionnaire is needed to determine if the combined symptoms of headache, dizziness, nausea, or vomiting occurred only among those who have been working in Thai traditional tobacco cultivation or not.¹⁴

The limitations of this study should be noted. It is difficult to estimate the true prevalence of GTS based on different definitions of GTS. As in many GTS investigations earlier conducted, there are no well-established criteria for the diagnosis

of GTS. GTS should be verified with a biomarker. In the current study, the definition of GTS refers to symptoms that occur after exposure to tobacco leaves within 2–3 days with typical symptoms including headache, nausea, vomiting, and dizziness, as well as other less common but possible symptoms of blurred vision, weakness, runny eyes, increased salivation, and increased perspiration.^{2,20,21}

In conclusion, dermal exposure is a major risk for GTS. The results of the present study represent the first investigation studying the prevalence of GTS among Thai traditional tobacco farmers in Nan

province, northern Thailand. The findings have indicated various contributing factors for GTS including working in wet conditions, doing activities such as watering and working with tobacco plants. Moreover, insufficient use of protective equipment may increase health symptoms related to GTS. For all these reasons, health education programs that discuss health risks exposure reduction are recommended.

Conflict of Interest: None declared.

Funding Source

This study was funded by the Thai Fogarty ITREOH Center, D43 TW007849 Fogarty International Center-National Institutes of Health, and the NIEHS Rutgers Center for Environmental Exposures and Disease, P3oES005022.

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