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EXPOSURE OF FEMALE FARMERS TO DUST ON FAMILY FARMS

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Abstract: Studies of dust on farms conducted to date, both in Poland and abroad, concern only health risk due to dust while performing selected occupations. The present study is a subsequent attempt to determine the year-round exposure to dust at workplaces in agriculture, and covers the workplace of a private farmer which is typical of Polish agriculture: a female farmer who is running a family farm together with her husband. Studies conducted on 10 mixed production family farms showed that women actively participate in farm activities. The occupations performed by women focus around the household - mainly the care of animals; whereas their field work consists primarily of manual jobs associated with crop cultivation, as well as auxiliary activities during harvest. Although the level of exposure to dust determined for female farmers remains statistically within the range of allowable conditions, this factor should be considered as an important health risk due to its high concentrations and pathogenic components.

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Key words: agricultural dust, female farmer, occupational exposure.

INTRODUCTION

In private farming, the task of a woman, except for running the household and rearing of children, is participation in running the farm - equivalent to occupational activities performed by females employed on a contract basis in various sectors of the economy [4, 8, 9, 13].

The work of women on family farms is associated with a specific workplace which differs from a typical work post in industry which is handled within a close organizational scheme, and protected from the point of view of an employee's work safety and hygiene. It is generally presumed that the lack of knowledge of the essentials of safety and hygiene among farmers is also observed among female farmers and unfavourably affects their health and safety.

The population of female farmers, who constitute nearly 50% among 4 million people employed in private farming in Poland, is an occupational group which will be covered in the future by the system of prophylactic health care developed at the Institute of Agricultural Medicine in Lublin [4]. Therefore, it is necessary to recognize their exposure to hazardous factors accompanying agricultural work in order to make decisions concerning prevention of occupational diseases.

Cases of occupational diseases which have been diagnosed among private farmers since 1992 are mainly dust-related respiratory diseases, where the etiologic factor is organic dust of plant and animal origin, commonly present in the rural environment, as well as a mineral component - free crystalline silica (SiO_2). Dust-related health effects in women have been also confirmed by the all-Polish survey of the state of health of rural population conducted by the Institute of Agricultural Medicine during 1986–1990 [2, 3, 7]. Based on the data concerning the employment of women in agriculture in the countries of the European Union (EU), it should not be expected that this problem will cease to exist in Poland upon entering and functioning within the EU [5, 12].

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It therefore seems justifiable to undertake studies of the occupational environment of women working on family farms and determine their exposure to agricultural dust. Studies of exposure to this risk factor conducted by the Institute of Agricultural Medicine among male farmers showed that their working conditions were hazardous [6]. The aim of the present study is to recognize the contribution of female farmers to the functioning of family farms, with particular consideration of the occupations accompanied by exposure to organic dust, and to determine the level of exposure.

MATERIAL

The material for the study was selected based on the data of the 1996 National Agricultural Census, published during 1997–1998. The study covered 10 typical mixed production family farms of 10–20 ha, where female farmers, who were also the co-owners, were selected from the point of view of their family situation. The farms are situated in the Lublin Region, within the communes of Jastków, Konopnica and Niemce.

The first group (A) were five women A1–A5 aged 42–46 (43.2 ± 2.2 on average) with two or three children still at school (over 14) and adult children. The farms were run by both spouses, with some help from the adult children who were studying at university or working outside their parents' farms. The mean size of a farm in this group was 14.5 ± 4.6 ha. The second group (B) were five female farmers B6-B10 aged 26–29 (27.6 ± 1.9 on average) who had two or three small children under 7 years of age. In this group, the farms were run by both spouses, with the assistance of one or both parents. The mean size of a farm in this group was 15.9 ± 4.9 ha. The size of farms in both groups was comparable, whereas significant differences were noted with respect to female farmers' age ($p < 0.001$).

The main crop cultivated on the farms in the study were cereals - 40–73% of arable land; other cultivation being root crops, green fodder, sweet corn and cauliflowers. All farms were engaged in animal breeding: cattle - up to 23, swine - up to 38. The provision of farms with basic technical production means was similar; the differences were observed only in equipment which facilitated work; all farms, however, possessed the essential equipment. All farms possessed tractors. Moreover, two farms of Group A and three farms of Group B possessed two tractors.

METHODS

The scope of the study covered methodological and organizational arrangements (preparation of the documentation and time-schedule measurements, selection of the material and instructions concerning keeping the time-schedule records), environmental studies of dust on selected farms, laboratory analyses of the collected dust samples (measurements of the concentration of the total dust inhaled and level of free crystalline silica), as well as the analysis of time-schedule measurements.

In order to select female farmers for the study, a Private Farm Chart was developed in the form of an abbreviated questionnaire which covered questions concerning the family members, taking into consideration those employed on the farm, the size of farm and cultivated land, animal breeding, and provision of the farm with technical production means. The level of exposure to dust was determined by the measurements of the total dust and free crystalline silica inhaled, as well as analysis of the time-schedule records. Due to the type of occupations performed in the working environment analysed, the dust sampling zones were located in the tractor's cabin, most often with the door open or windows half-open; outdoors during manual cultivation activities, repair and household jobs; in animal rooms, fodder stores and inside workshops.

Analyses of airborne dust were carried out with the use of gravimetric method and individual samplers (aspirators: AP-2 produced by ORMED, Łódź, Poland and SKC/224-PCEX7 produced by SKC Ltd., Dorset, UK) - for dust concentration and colorimetric method (spectrophotometers: Specol 11 produced by Carl-Zeiss, Jena, Germany, and Marcel Mini Eco produced by MARCEL Sp. z o.o., Warsaw, Poland) - for determination of free silica in the inhaled dust. Measurements were performed in series which covered two consecutive samples, the duration of a series generally being 2 hours. Time-schedule observations concerned the annual work cycle and covered the records of occupations kept by the people examined. The 'Work on Family Farm Chart' designed for everyday registration of occupational activities by the female farmer herself, contained questions concerning the duration of work, performer or co-performer of an occupation, machines and equipment used, and subjectively perceived factors of the working environment accompanying work (mainly dust, but also mineral fertilizers, pesticides, other chemical agents, noise, vibration, unfavourable elements of the thermal environment, and biological hazards - understood as contact with animals and plant raw material). This documentation allowed us to obtain necessary information in order to assess the exposure, the type of occupation performed, time devoted to this occupation, and the effective working time. Time-schedule records concerning 10 female farmers were analysed.

Dust measurements covered the occupations which made up the working cycles of the female farmers on the farms analysed. For each occupation, mean geometric concentration was calculated from the values obtained in the series, as well as the confidence interval for the mean value on the probability level of 95%, with the number of degrees of freedom $f = n - 1$, where n was the number of reference measurements in series. Farmers' exposure to dust was evaluated by the method of comparing the mean weighted concentration with an occupational exposure limit value (OEL), selected according to the level of SiO_2 in the agricultural dust examined, with the application of

Table 1. Annual working time-schedule of female farmer A1.

Type of occupation	Working time of individual occupations in particular months during one year (hours)												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Ploughing									12.5	24.0	3.5		40.0
Harrowing					2.5				7.0	3.0			12.5
Tilling			5.0										5.0
Disk harrowing				7.0			2.5	30.0					39.5
Manual care of crops				17.5	7.5	11.5		2.0		7.0			45.5
Sowing of mineral fertilizers				4.5	2.0								6.5
Manure spreading	26.5		9.0		2.0			4.0					41.5
Sowing with seeder				12.5						2.0			14.5
Potato planting					6.0								6.0
Spraying					7.5				0.5	1.0			9.0
Grain treatment										0.5			0.5
Hay work (tedding, raking)						14.5	1.5	4.5	10.5				31.0
Potato digging									5.0				5.0
Fruit picking by hand							35.0	0.5	0.5				36.0
Harvesting, sorting of vegetables				9.0	6.0				2.0	8.5			25.5
Care of animals	142.5	136.0	164.5	160.0	137.5	160.0	142.0	144.0	138.0	139.0	141.5	147.0	**1752.0**
Grain crushing	3.5		2.0				1.0	2.0	2.0	1.5	1.5		13.5
Wood cutting with chain saw	27.5		20.0	5.0	4.5					7.5			64.5
Wood cutting with circular saw										5.0			5.0
Other farm activities	19.0	4.0	4.0	12.0	8.5			1.5	2.5	23.5	4.5	4.0	109.5
Manual reloading	19.0	8.0	12.5	24.0	6.5	27.0	20.0	26.0	37.5	12.0	5.0	5.0	**202.5**
Repair		4.0	16.5	4.0	7.0			1.5	2.5	4.5	7.5	0.5	48.0
Transport	8.5	12.0	7.0	8.0	22.5	13.5	16.5	15.0	44.0	22.5	10.0	5.5	**185.0**
Effective working time:													
- in hours	246.5	167.0	243.5	**263.5**	238.5	226.5	219.0	227.0	268.5	262.0	173.5	162.0	**2697.5**
- in% of legal working time	146.7	99.4	126.8	**149.7**	142.0	128.7	114.1	129.0	145.9	142.4	103.3	88.0	**126.3**

the criterion of confidence interval of this mean value. The value of the mean weighted concentration was calculated by use of the following formula:

$$C_{TWA} = \frac{\sum_{i=1}^{n} C_i \cdot t_i}{8 \cdot N}$$

where: C_i - mean geometric dust concentration (for each activity in a full work cycle) during the measurement period t_i, (mg m^{-3});

t_i - duration of the measurement period (i. e. working time for each activity), [h];

N - number of obligatory work days in full working cycle;

8 - is 8-hour work shift, [h].

In the case of the analysed workplace of a female farmer on a family farm the $N \cdot 8$ product is the legal working time in a given annual work cycle of a farmer. The upper and lower limits of the confidence interval of the mean weighted values C_{TWA}^{L} and C_{TWA}^{U} were calculated similar to C_{TWA}, i.e.:

$$C_{TWA}^{L,U} = \frac{\sum_{i=1}^{n} C_i^{L,U} \cdot t_i}{8 \cdot N}$$

where: $C_i^{L,U}$ are limits (lower L and upper U) of the confidence intervals of mean geometric dust concentrations C_i determined for individual measurement period 'i'.

The level of exposure to dust at workplaces is interpreted in the following way:

- as hazardous - when confidence interval of the mean weighted value is above the allowable value OEL
$$OEL < \{C_{TWA}^{L}, C_{TWA}^{U}\};$$
- as allowable - when OEL value remains within the confidence interval of the mean weighted value
$$\{C_{TWA}^{L}, OEL, C_{TWA}^{U}\};$$
- as safe - when confidence interval of the mean weighted value is below the OEL value
$$\{C_{TWA}^{L}, C_{TWA}^{U}\} < OEL.$$

In order to determine the dynamics of changes in exposure to dust during an annual work cycle mean monthly weighted concentrations were calculated.

RESULTS

Duration of work. Time-schedule analyses on 10 selected farms were started at the beginning of June during the first year of the study, and were conducted throughout the whole year. Based on the time-schedule records obtained, 31 types of occupations were selected connected with the cultivation of soil and crop, fertilizing, sowing, planting, crop protection, harvesting, household occupations, such as care of animals, threshing of cereals, cleaning and crushing of grain, and other occupations such as repairs, transport or reloading.

The time-schedule image of the effective work of female farmers, i.e. work associated with running the farm together with her spouse, is presented in the examples of female farmers A1 and B8 (Tabs 1 and 2). Working time of a female farmer, calculated for each month, is expressed in the absolute form - in hours, and relative form - in percentage of the legally established working time.

In Group A of older farmers, the total time of performing all occupations registered in annual time schedule records is within the range 1,914.5–3,393.5 hours, 2,573.9 ± 755.4 on average. These values, expressed in percentage of the legal working time, are from 89.6% to158.8% - 120.5% ± 32.6% on average (Fig. 1). In Group B of younger farmers the total annual time of performing all occupations is from 1,526.0 to 3,344.5 hours - 2,532.0 ± 1,168.4 on average. These values expressed in percentage of the legal working time are from 71.4% to 156.6% - 118.5 ± 54.7 on average. No statistical differences in the working time load were observed between the two groups ($p < 0.6$).

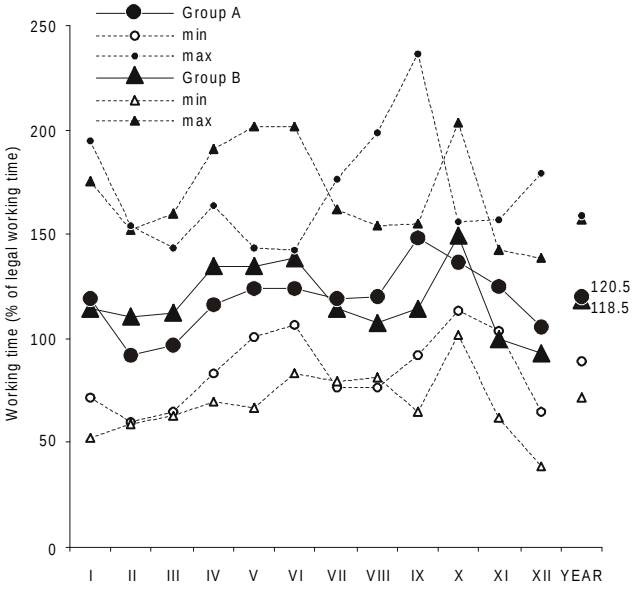

Figure 1. Distribution of relative working time of female farmers on private farms (Group A – older women, group B – younger women).

The comparison of the average working time distributions during the subsequent months determined for Groups A and B showed a similar course of both characteristics; in the first half-year, however, the values of working time were greater in Group B, while in the second half-year - they were greater in Group A. The characteristic feature of the distributions is their maximum in September or October: in Group A in September the mean value was 147.8% (with the scatter of individual values 92.1–236.4), and in Group B in

Table 2. Annual working time-schedule of female farmer B8.

Type of occupation	Working time of individual occupations in particular months during one year (hours)												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Manual care of crops			1.0		5.0	83.0	34.0	16.0					**139.0**
Manual sowing, planting				27.0	12.0								39.0
Manual harvesting of cereals							21.0	6.0					27.0
Hay work (tedding, raking)					3.5								3.5
Harvesting, sorting of vegetables		0.5	0.5	8.0	14.0		2.0	15.0	26.0	40.0			106.0
Cutting of leaves, tops									4.0	23.5			27.5
Digging of sugar beets										15.5			15.5
Hand fruit picking						20.0							20.0
Care of animals	238.5	205.5	237.5	228.5	258.0	109.0	129.0	160.0	221.0	249.5	220.5	199.0	**2456.0**
Grain threshing	20.0	19.5	21.0	13.5	9.5	7.0	7.0			1.5	14.5	15.0	**128.5**
Grain crushing										1.5			1.5
Grain cleaning		0.5	3.0	8.5									12.0
Other farm occupations			6.0	5.5									11.5
Manual reloading	36.0	29.0	37.0	45.0	36.0	14.0	5.5	33.5	34.0	43.5	3.5	40.5	**357.5**
Effective working time:													
- in hours	294.5	255.0	306.0	336.0	**338.0**	233.0	198.5	230.5	285.0	**375.0**	238.5	254.5	**3344.5**
- in% of legal working time	175.3	151.8	159.4	190.9	**201.2**	132.4	103.4	131.0	154.9	**203.8**	142.0	138.3	**156.6**

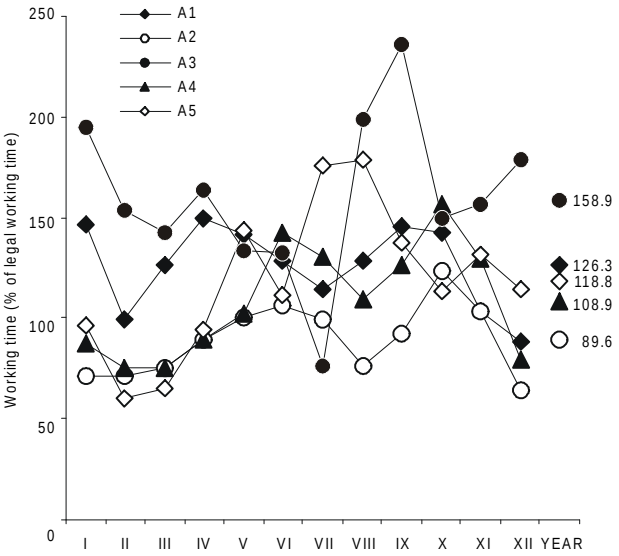

Figure 2. Distribution of relative working time of individual female farmers A1-A5 (older women) on private farms.

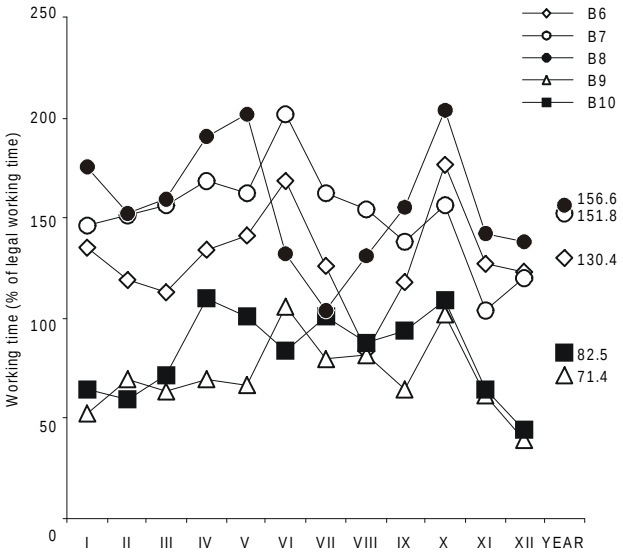

Figure 3. Distribution of relative working time of individual female farmers B6-B10 (younger women) on private farms.

October the mean value was 149.2% (with the scatter 101.6–203.8). The distributions of monthly working times of individual female farmers are presented in the form of graphs (Figures 2 and 3). The analysis of data indicated a great inequality in work load among the women in the study over the annual working cycle analysed. In addition, the analysis showed that the monthly working time of female farmers was high, and most often exceeded the legally established values: 200% of the working time at maximum (236.4% in September - female farmer A3, 203.8% in October and 201.2% in May - farmer B8, 201.4% in June - farmer B7).

During the period analysed, care of animals, which is the main component of the female farmers' working time, took the greatest amount of time - from 61.7% to 83.0% of the total working time on the farm, followed by manual cultivation activities - up to 11.4%, harvesting and assortment of vegetables - up to 9.4%, and loading and unloading - up to 12.9%. Women actively participate in the process of plant harvesting and perform the great number of manual jobs, such as: hay work, cutting tops of sugar beets and carrots, harvesting and sorting of vegetables, and fruit picking. They also perform occupations using tractors and machines, although less often and for a shorter working time. These are cultivation activities, transport, as well as threshing, grinding and cleaning of grain, and cutting wood with chain and circular saws.

Dustiness. The level of dustiness at workplaces analysed varies according to the type of occupation. Individual values of dust concentrations fall within a wide range, e.g. confidence intervals during grain threshing are 28.9–114.6 mg m^{-3}. Mean values calculated for individual occupations range from 1.3 to 57.5 mg m^{-3}. The following values of dust concentration were obtained for the subsequent groups of occupations: cultivation activities - 5.1–23.6 mg m^{-3}; fertilizing 4.2–9.9; sowing and planting 3.0–7.5; plant protection activities 3.5–8.9; plant harversting 3.3–19.3; household occupations 3.0–57.5; and other activities 1.3–3.9 mg m^{-3}. The highest levels of dust were noted during household occupations: threshing of grain with a thresher in a household room - 57.5 mg m^{-3} (confidence interval: 28.9–114.6), and in the fodder store during milling of grain - 34.4 mg m^{-3} (confidence interval: 12.9–91.8) (Fig. 4).

The following levels of free crystalline silica were observed in airborne dust in farmers' respiratory zone while performing individual groups of occupations: cultivation activities 5.6–15.0%; fertilizing, sowing and

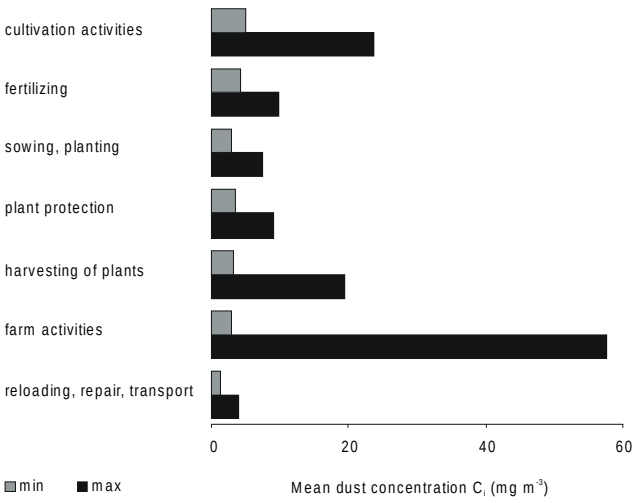

Figure 4. Range of mean maximal and minimal concentrations of dust accompanying various occupations performed by female farmers during an annual work cycle.

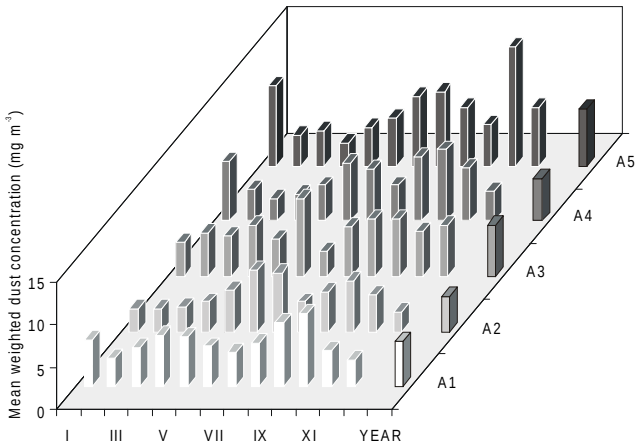

Figure 5. Monthly distribution of exposure to dust in individual female farmers A1-A5 (older women).

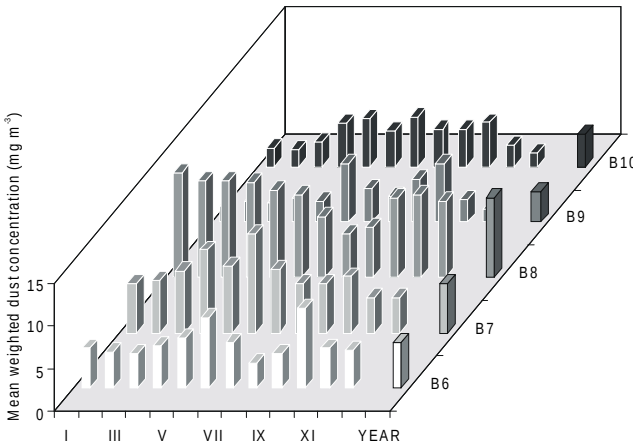

Figure 6. Monthly distribution of exposure to dust in individual female farmers B6-B10 (younger women).

planting 6.4–11.0%; plant harvesting 2.0–13.6%; household occupations, such as: animal care - up to 2.3%; threshing and grinding of grain 4.4–11.6%, and wood cutting - up to 3.0%.

Level of exposure. The evaluation of the level of farmers' exposure to dust on family farms covered 10 female farmers and was based on the results of annual time-schedule records, as well as on mean values of dust concentration equivalent to individual occupations. Mean weighted values were calculated for everyone in the study. These values covered annual and monthly work cycles, provided information concerning the dynamics of changes in the exposure to dust during an annual work cycle, and enabled us to detect the periods of the highest exposure.

Monthly analysis of mean dust levels showed an uneven distribution of female farmers' exposure during the whole year, corresponding to inequalities in annual working time load at the workplace analysed. Mean values of monthly concentrations of dust calculated for female farmers of Group A were within the range 2.6–14.1 mg m^{-3}; while for Group B these values were from 1.5–12.2 mg m^{-3} (Figures 5 and 6). The analysis of distributions in the groups showed that maximum values of exposure were observed in June - 6.7 and 8.1 mg m^{-3} and in October - 6.9 and 7.5 mg m^{-3} in Groups A and B respectively. In the group of younger female farmers (Group B) higher levels of exposure were noted during the first half-year, compared to older farmers (Group A), whereas in the second half-year higher exposure levels were observed among women of Group A (Fig. 7). This is due to the differences in the working time load noted in both groups (Fig. 1), as well as to the percentage of occupations accompanied by high levels of dustiness.

Mean weighted values, representing an average level of dustiness at the workplaces of 10 female farmers in the study, were within the range 3.5–9.3 mg m^{-3}, confidence intervals for these extreme values being 1.5–8.3 and 4.0–21.6 mg m^{-3}. In both groups of farms, mean weighted concentration values were similar (the differences were not statistically significant): in Group A - 5.4 mg m^{-3} (confidence interval 2.2–13.4), in Group B - 5.5 mg m^{-3} (confidence interval 2.2–13.8); while the differences in the levels of exposure to dust are greater in Group B, compared to Group A (3.5–9.3 and 4.1–6.8 mg m^{-3} respectively). The calculated values of confidence intervals of mean weighted dust concentration values are generally wide, which confirms the occurrence of changeable conditions accompanying work and effecting the level of dustiness (Fig. 8).

In order to interpret the results of the study from the point of view of hygiene, the value 4 mg m^{-3} was adopted as the occupational exposure limit, as the value most equivalent to the features of agricultural dust accompanying the occupations performed by female farmers [11]. This was a mixed dust, containing varying proportions of animal, plant and mineral components, including free crystalline silica below the level of 10% on average. It should be emphasized that the contents of this component in some of the individual samples examined exceeded 10%, especially during crop cultivation activities.

It was observed that 8 of 10 annual values of mean dust concentration describing the level of exposure of the selected female farmers remained above the occupational exposure limit; in one case the mean weighted value, together with the whole confidence interval, was over OEL, which is equivalent to hazardous conditions (young farmer B8), while in 7 farmers the values of confidence intervals for mean weighted concentrations were allowable, although close to the lower limit. Therefore, the exposure of these female farmers to dust should be considered as potentially hazardous.

DISCUSSION

The present study is an attempt to determine exposure to dust while performing selected occupations at workplaces in agriculture. It pertains to the workplace of a private farmer typical of Polish agriculture, in this case a female farmer running a farm together with her spouse.

According to the data of the 1996 Agricultural Census, 7,497,500 Polish inhabitants were private farmers together with their family members, including 4,158,800 of the population who were at productive age, i.e. females aged 18–59 and males aged 18–64; females constituted 44.7% of people in this group (1,860,200). This study covered women who were running farms of mixed-production profile, which are the most common in Polish agriculture, each covering an area of 10–20 ha. This group comprised the greatest number of farms declaring themselves as developing farms (33.3% of the total number of farms). Therefore, it should be expected that these female farmers will continue to perform the occupation of a farmer and will be exposed to strenuous and hazardous factors of the agricultural working environment [10].

Due to the specific character of production processes in agriculture, people employed in this sector of the economy are exposed to dust in changeable conditions, with a variety of activities, changeable concentrations and composition of dust, workplace and daily exposure, as well as the duration of the working cycle, which in the case of plant or plant-animal production covers the whole year. The results obtained to date concerning the exposure of female farmers to dust confirm this changeability in all the above-mentioned aspects. It was observed that the level of female farmers' exposure to dust changed from month to month according to technologically conditioned distribution of occupations during the work cycle, these occupations, and the differences in the levels of dustiness accompanying the work. Differences in the level of dustiness were noted in association with the type of occupation and variety of conditions accompanying work, such as: weather and soil conditions, degree of humidity of the raw material collected, type of machines and equipment applied, and method of their operation. It was observed that during a year, female farmers were unequally loaded with work of similar distribution dynamics, and the level of this work load varied according to individual features of the farms in the study.

The studies conducted did not show differences between mean values of the working time and exposure to dust among younger and older women. Working time of a female farmers, as well as the level of their exposure to dust, was typical for individual farms and associated with the type of farm: type of crops, technologies applied, cultivated area, size of animal-breeding, number of people co-operating in running the farm, distribution of tasks between these people, and finally, with neighbour services provided. Changes in exposure to dust of each individual female farmer during the subsequent years will depend on changes in the features of their farms. Therefore, it may be expected that the exposure will be repeated in subsequent years, provided that there will be no changes in the production profile, technologies applied, cultivated area and the size of breeding stock.

The study of exposure to dust among female farmers showed that although their working conditions remain within the range of allowable conditions, high values of mean weighted concentrations which exceed the maximum allowable concentrations and dust pathogenic

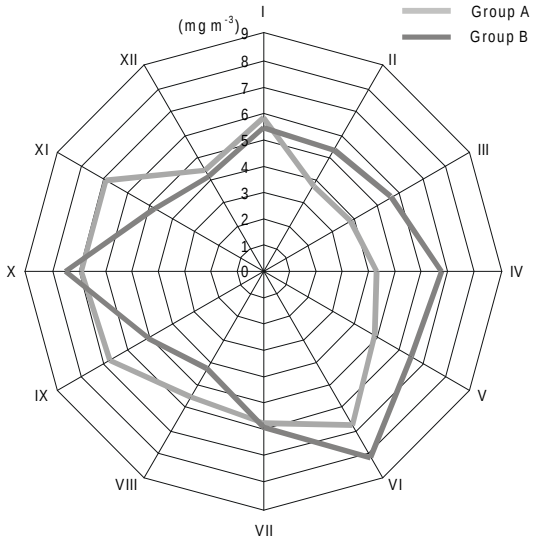

Figure 7. Annual distribution of exposure to dust in female farmers of Group A (older women) and Group B (younger women).

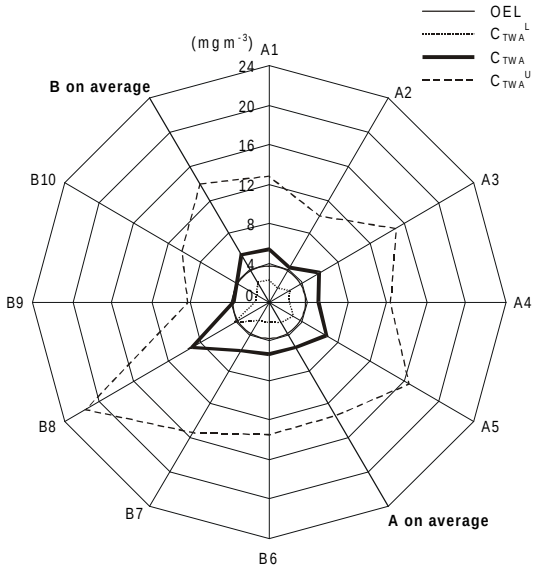

Figure 8. Mean weighted concentrations of dust C_{TWA} and lower and upper limits of the confidence interval $\{C_{TWA}^{L}, C_{TWA}^{U}\}$ determined for individual female farmers of Groups A and B.

components (organic component including microflora and mineral component) should be considered as indicators of high health risk in females exposed to agricultural dust.

CONCLUSIONS

- Women actively participate in running of family farms.
- Occupations performed by females focus around the household, whereas in the field these are mostly manual jobs concerning care of crops and auxiliary activities during harvesting of crops.
- The greatest amount of time is devoted to animal care, including milking, which presently requires a greater work expenditure in order to obtain the required high microbiological purity (according to strict European standards).
- The occupations performed by female farmers are accompanied by agricultural dust - a potential etiologic factor of occupational respiratory diseases due to the high level of exposure to dust and its composition.

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