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Original Research Article

The Effect of Greenhouse Structural Features on the Determination of Greenhouse Insurance Premium

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ABSTRACT

The structures that are built to create suitable environments for growing plants by controlling environmental conditions by artificial means are called greenhouses. Greenhouses should be made in accordance with the characteristics of the geographical and climatic conditions in the regions to be established. Some of the important parameters here are the roof geometry of the greenhouse, the profile thickness to be used, the direction of the greenhouse installation, the geographical terrain and the height of the flooded wall. In our country, where tropical climate characteristics have been observed recently, it has become increasingly common for greenhouse growers to apply for greenhouse insurance against natural disasters. In addition to the severity of the natural disaster, the static resistance properties of the greenhouse are also effective in the amount of damage that occurs in greenhouses in natural disasters. The level of being affected by natural disasters will be different between the greenhouse built by the standards and the greenhouse built without complying with the standards. For this reason, it would be more appropriate to determine the insurance premium value according to the strength characteristics of the greenhouse. In this study, the features of SERAPRO software, which is tried to be developed for projecting and evaluating greenhouses, have been introduced. With the software in question, it will be possible to project the greenhouse with the most suitable construction features and to produce an analysis report showing the status of the existing greenhouses. According to the results of the analysis, it is thought that the greenhouse insurance policies already issued by TARSİM will be charged with more scientific scaling.

Keywords: Greenhouse Design, Greenhouse Static-Strength Calculations, Construction, Greenhouse Insurance

INTRODUCTION

In addition to its critical importance for the world population, the agricultural sector has a unique structure as a susceptible field of activity, highly affected by economic, social, political, technological and personal risks. From this point of view, the effective functioning of agriculture in the nutrition of humanity is directly related to managing risks threatening agricultural production. For this reason, developed countries, various protectionism policies, "Risk Management Programs" and an important part of these programs; carry out risk-sharing and transfers through "Agricultural Insurance Practices". In our country, an insurance mechanism was introduced to ensure the risks threatening the agricultural sector. For this purpose, the "Agricultural Insurance Law" dated 14/06/2005 and numbered 5363 was enacted (Tarsim 2021a).

Producers and growers registered in the Turkish Agricultural Insurance System/Agricultural Insurance Pool (TARSİM) and the Ministry of Agriculture and Forestry Registration Systems are optionally provided to insure their agricultural assets (Tarsim 2022a).

To support the individuals engaged in agriculture economically, to prevent them from being in a difficult situation against various natural disasters and to ensure sustainable production, the need for insurance arises as in other areas of life. In our country, although it is not compulsory, a joint insurance pool system has been developed with the participation of many state institutions and the private sector. The developed common pool was named "Agricultural Insurance Pool" (TARSİM). Insurance made by TARSİM covers all situations that threaten production, such as natural disasters such as floods, fires, storms, injury or illness of poultry or deterioration of the farmer's health. In our world, where global climate change occurs, it has become necessary to support the producer to prevent food shortages and related social movements. The main goal of TARSİM is to eliminate the damage that may occur, if not all, with the least damage to the business. For this purpose, the Agricultural Insurance Pool operates through 7 different insurance types.

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These are, in order;

- Greenhouse Insurance
- Herbal Product Insurance
- Cattle and Ovine Life Insurance
- District-Based Drought Yield Insurance
- Poultry Life Insurance
- Beekeeping Insurance
- Aquaculture Life Insurance

Greenhouse insurance, one of the types mentioned above, has recently become widespread in our country. Greenhouse insurance is important in terms of providing sustainable opportunities for greenhouse cultivation. The installation costs of greenhouse cultivation are high. However, this farming model is a crop production model that is incomparably productive with open field crops.

In today's world, where food crises are seen, greenhouse installation and operating costs are important in economical greenhouse cultivation. During the project, planning made by the greenhouse construction technique positively affects the operating costs in greenhouse cultivation. To keep the initial investment and operating costs low in greenhouses, plant growth factors such as light, temperature, humidity and carbon dioxide content of the air must be planned to provide optimum conditions. The high temperature that occurs in the greenhouse due to intense radiation in summer should be removed from the greenhouse environment and growth factors should be kept at the desired level as much as possible. What is expected from a good greenhouse construction is to provide the necessary climatic conditions for plant growth throughout the year and to keep these conditions at the desired level as much as possible by making use of technical opportunities (Can 2006). In addition, greenhouses are covered with a permeable cover material so that visible rays, which are a part of the total radiation essential for plant growth, reach the greenhouse and receive sufficient light in winter when the radiation is very low. Although the order of them varies in different climatic regions of the world, the most used cover materials are polyethylene, glass and polycarbonate, respectively (Topçu 2007).

Glass greenhouse area in our country is more than other Mediterranean countries. Compared to these countries, flat glass prices and labor costs are cheaper in our country. In addition, the higher number of rainy and cloudy days compared to other Mediterranean countries, high light transmittance and excessive humidity in the greenhouse in winter cause less condensation, which leads to the preference of glass cover material (Titiz, 2004). Steel is used as the construction material in traditional glass greenhouses and is attached to the glass sheet with putty. In modern greenhouses, aluminum is used as the framework, the glasses can be fixed in water and airtight way with a corded clip system, and the ventilation surface is up to 40%.

Compared to previous years, although there has been progress in terms of reaching a sufficient level of ventilation openings, plastic greenhouses without roof ventilation can still be encountered. Although the roof ventilation opening was only 5% in the old glass greenhouses, the roof ventilation area increased to 10-25% in the glass greenhouses established with the investment incentives applied between 1990-1995 (Titiz 2004). To reduce the greenhouse temperature, in addition to roof ventilation, curtains suitable for shading and high-pressure fogging units are used inside the greenhouse. Such additional greenhouse equipment also affects the loads on the greenhouse construction.

(Çanakçı 2005), reported that the ratio of the ventilation openings to the greenhouse floor area of the greenhouses in the Antalya region, where 57% of the total greenhouse areas in Türkiye are located, is less than 15%. In the greenhouses in Antalya province Kumluca district, it is determined that this rate varies between 3.20-24.54%, with an average of 12.73%. Cold drawn angle steel, flat bar and T profiles are used in glass greenhouses in this region. Generally, joints in construction are made by welding. The subject of protective paint is neglected and most of the time a single coat of primer (sülyen-anticorrosion) paint is sufficient. Glass cement is used for glass fixation. Building a long-lasting greenhouse with the desired properties with mentioned material and manufacturing method is impossible. In developed countries, the materials used in greenhouse production are specially drawn from the sheet in the cold, bolt holes are drilled and hot galvanized after all processes are completed. Thus, a maintenance-free structure is created because it is easy to assemble and disassemble, light, long-lasting and galvanized (Emekli *et al.* 2008).

(Saltuk 2005) carried out research to determine the existing structural features and problems of plastic-covered greenhouses in the Mersin region and it is determined that 53.5% of the plastic greenhouses in Tarsus, Erdemli, Silifke and Merkez districts were manufactured without a project**.** As a result of the survey, it is determined that 55% of the growers prefer to have their greenhouses installed by the masters who produce in the region. Most companies that undertake the greenhouse construction (88.7% of the companies included in the survey) tend to build block greenhouses and mostly use steel pipe or profile material (71.8%) as load bearing material in greenhouses. One of the study's most important findings is existence of insufficient ventilation openings in greenhouses especially in the Mersin region.

One of the most important greenhouse cultivation problems is winter air conditioning. Insufficient heating during the winter months when the indoor temperature of the greenhouse drops to a level that will limit plant growth causes low yield and limitation of the production variety, while it also brings problems such as the necessity of using hormones to increase yield (Kaya and Herzadin 1990, Titiz 2004, Topçu 2007).

(Kumova *et al.* 1996) developed a computer program that solves the static solutions of lattice beam systems, frequently used in agricultural structures, using the node method. (Üstün 1998), developed a computer package program to be used in the preparation of greenhouse projects. The developed program a) determines the moving and fixed loads on the greenhouse, b) analyzes the static analysis of the truss beam system using the node method, c) optimizes the material losses by considering the boundary conditions for the different dimensions of the profile elements used in the truss system. d) Using the DIN 4701 standard, it calculates the heat requirement according to weeks, determines the required amount of fuel according to different fuel types, prepares the quantity and estimate summary according to unit prices, and prepares the appearance and detail drawings.

During the greenhouse project design, it is inevitable to consider many factors affecting the greenhouse columns as well as the selection of the appropriate profile. These factors are divided into live and dead loads. While designing the greenhouse roof, wind load, snow load, the number of plants to be hung on the roof, the weight of the worker to work on the greenhouse are considered as live loads. In contrast, the weight of the profile and cover material and factors such as earthquake are considered as dead loads, it is of absolute importance for the calculation of the profile thickness of the columns that will carry the greenhouse roof. In these calculations, the project should be carried out considering the latest standards issued by TSE.

This study will discuss the importance of the structural characteristics of the greenhouse in determining greenhouse insurance premiums. Additionally, the contribution of the software for the greenhouse construction, which is tried to be developed within the scope of the doctoral thesis, to the determination of insurance premiums will be examined. The software called SERAPRO, in which essential values of greenhouse structure can be entered, is planned to be a construction project program specifically for greenhouses with a static structure compatible with geographical and climatic conditions. It is thought that the software will make a significant difference in the determination of greenhouse insurance policy costs.

MATERIALS AND METHODS

In this section, information is given about the hardware and programs that will be used during the writing of the SERAPRO computer program, the criteria used to determine the greenhouse insurance policy costs defined as the problem, and the methods followed in project calculations such as strength.

Material

Computer Features and Programs

The expert system planned to be prepared within the scope of this study will be a greenhouse project design program related to the greenhouse construction technique. For this reason, it was named "SERAPRO" to remind the words "sera" and "project". Since the SERAPRO expert program tests all the values in the database, a computer with high speed and capacity is required.

In the preparation of the SERAPRO program, the object-oriented Microsoft Visual 2017 programming language, which works under all 64-bit supported versions of the Windows operating system, is used. C# was developed by Microsoft in the C programming language. It is also an event-driven, high-level, object-oriented and visual programming language. The SERAPRO program is written using the necessary functions and expressions of this programming language, which is fully compatible with Windows.

The mathematical basis of this study is the matrix displacement method. In the matrix-displacement method, the establishment of the stiffness matrix, which provides the transition from rod end displacements to rod end forces, has an important place. The location of all the rods and nodal points of the carrier system, with the global coordinate set; the individual positions of the bars can be defined by the local set of coordinates (Armenakas 1991, Çakıroğlu *et al.* 1970, Çakıroglu *et al.* 1992, Fork 2002).

These calculations are used in the powerful instruction set of the C# language. After extracting the software's algorithm, it was translated into C# code. SQL Server commands were used as a database. All climatic and geographical data are captured when necessary and coded into the static strength calculation in the background. The first goal of the study is to develop software that can design and analyze greenhouses according to our country's geographical and climatic characteristics within the framework of TSE standards. The mentioned software aims to determine the profile type and minimum wall thickness that can meet the geographical and climatic conditions of the region by using the most common roof types. The aim of the study can be summarized as creating the proper construction.

The main secondary objective of the study is to create software to determine the greenhouse insurance policy costs made by TARSİM with more scientific criteria.

Method

In the study, TARSİM greenhouse insurance application principles were primarily examined. In practice, the deficiencies encountered in the pricing of greenhouse insurance policies were determined. The possibility of using the program to determine greenhouse insurance premiums will be discussed.

In TARSİM greenhouse insurance, the grower must first register in the Greenhouse Registration System. It is tried to determine the material damages caused by the risks specified in the policy to the greenhouses and the products in them that are deemed suitable for insurance. Then, the part up to the insurance amount is insured. The risks covered are specified in the policy. In implementing these general conditions, the State Supported Greenhouse Insurance Tariffs and Instructions are considered. From this point of view, the situations covered and not covered by the coverage and the definition of the guarantees are specified in the policy. However, regarding the pricing of this policy, the criteria for the pricing set in the State Supported Greenhouse Insurance Tariffs and Instructions section are listed in articles and tables. According to the said criteria, the amount of compensation paid to the manufacturer in case of damage is also determined by these instructions.

RESULTS AND DISCUSSION

Principles Considered by TARSİM in Greenhouse Insurances

In the TARSİM system, insurance is made for the building materials of the greenhouse, the technical equipment inside and the herbal products grown in the greenhouse according to the results of risk examination and assessment. The risks covered by the policy can be counted as hail, earthquake, vehicle collision, storm, tornado, fire, landslide, flood, weight of snow and direct damage to the covering material and/or construction assets of the greenhouse. If one or more of the disasters specified within the scope of TARSİM General Conditions, Tariffs and Instructions occur, the dismantling, cleaning and transportation costs of the wreck are covered by TARSİM (Tarsim, 2021b).

For high tunnels, only the product and plastic covering materials are insured against the risks of hail, storm, tornado, fire, landslide, vehicle collision, earthquake, and flood. For low tunnels, insurance is only made for the product inside against the risks of hail, loss of quality, storm, tornado, fire, landslide, earthquake, vehicle collision and flood. While the greenhouses are being insured, the effect ratio of some construction-related items on the policy cost has been determined. However, it is impossible to make a static calculation about the greenhouse using the mentioned materials. Instead of static analysis, the age, material properties and amount of the greenhouse construction, the snow density of the region, and the scoring method were used. Below are the items under the heading of Risk Analysis-Evaluation Principles and Risk Categories in Greenhouse Insurance, under the General Conditions of the State Supported Greenhouse Insurance for the year 2022, and which features are taken as a basis during the insurance. The mentioned evaluation principles and the criteria considered by TARSİM to evaluate the greenhouse are listed. The scoring of each item below is included in the State Supported Greenhouse Insurance Tariffs instruction. The loan value is determined by the monetary amount corresponding to the value resulting from the sum of the points above.

Risk Analysis-Evaluation Principles and Risk Categories in Greenhouse Insurance

In greenhouse insurance, for storm coverage when determining risk categories.

a) The age of the greenhouse,

b) Number of cracked and patched glass panels in the greenhouse,

c) Tears and holes in the plastic cover material,

ç) The fastening elements used in the connections of the glass and plastic cover material with the construction (framework) are of a type and condition to fulfill their functions properly,

d) Construction (framework) material,

e) Presence of a windbreak,

f) Presence of surrounding concrete (foundation wall) on all four sides of the greenhouse,

g) The clips must be mounted horizontally in plastic greenhouses with gable roofs,

ğ) Connection status of the cover to the surrounding concrete (foundation wall) in the greenhouse,

h) Whether there are porches in greenhouses,

ı) Construction (framework) connection unit,

i) The condition of the basic structure of the greenhouse,

j) The factors of the use of nails are considered in the greenhouse cover.

In greenhouse insurance, for those coverage when determining risk categories.

a) Construction (framework) material,

b) Construction (framework) connection unit,

c) The factors of tears, holes and disruption in the plastic cover material are considered.

In greenhouse insurance, when determining risk categories, for flood coverage.

a) The height of the perimeter wall above the outdoor ground level,

b) Outdoor drainage condition,

c) Indoor drainage condition,

ç) The slope of the greenhouse floor for the removal of surface waters,

d) The height of the root zone of the grown crops from the greenhouse floor,

e) The height difference of the greenhouse floor from the nearest stream and sea level,

f) The proximity of the greenhouse to a stream, lake or sea,

g) Presence of the perimeter wall (foundation wall) in the greenhouse,

ğ) In the greenhouse, the factors of the connection status of the cover to the perimeter wall (foundation wall) are considered.

In greenhouse insurance, for snow and hail coverage when determining risk categories.

a) The altitude of the land,

b) Type of gutter material,

c) The shape of the greenhouse roof (for flat roof greenhouses),

ç) The condition of the poles under the gutter,

d) Shear situation in the greenhouse,
e) Construction (framework) connection unit factors are considered.
In greenhouse insurance, for landslide coverage when determining risk categories.
a) Retaining walls in greenhouses on sloping lands,
b) The structure of the greenhouse floor,
c) The effect of slope, water, and similar conditions,
ç) The factors of the condition of the greenhouse's basic structure are considered.

Deficiencies in TARSİM's Greenhouse Insurance Premium Determination System

While determining the cost of the greenhouse insurance policy, there is no clause in the policy about the adequacy or level of adequacy of the construction that provides the structural integrity of the greenhouse. While TARSİM is the organizer and main contractor of the insurance system, private insurance companies invoice the greenhouse insurance policies. According to TARSİM, the existence of the product, cover and steel trio in the greenhouse is necessary for the insurance of a greenhouse to be established. The policy's cost consists of four categories: the current market price of the greenhouse: construction, covering material, technical equipment (irrigation, shading, humidification, heating, and ventilation systems, etc.) and labour.

According to the TARSİM Insurance Tariff Regulation, the damage rate is determined as a ratio of the insurance cost of each element. Damage rates are determined separately in the cover element according to the soft plastic, hard plastic, glass cover type; in the technical equipment element, according to the air conditioning systems, irrigation and drainage systems, fertilization systems, energy systems, plant transport and cultivation systems and other technical equipment systems (Tarsim 2021c). In the same regulation, the year of use of the greenhouse construction (of the framework) and greenhouse covering material is affected at a specific rate on the insurance cost in greenhouse insurance. The scoring method was determined within the snow load. There is a multiplier factor for the snow load according to the greenhouse’s altitude. But scientifically, the most important way to compensate for the snow load is to increase the greenhouse roof tilt angle. Increasing the roof slope angle is a more accurate method to prevent the snow load from accumulating to the roof. In addition to the roof slope angle, the static strength calculation of the greenhouse construction should be made. It is essential to determine the profile wall thickness, which will prevent the collapse of the structure against snow load, by calculating with scientific methods.

The multipliers to be applied to the premium price based on coverage have been created according to the risk category determined against disasters such as tornado, storm, flood, snow weight and landslide in the said tariff instruction. The greenhouse insurance tariff guideline has created a table for each disaster (hurricane, storm, flood, snow weight, landslide). In these tables, geographical regions are determined by letters. A multiplier is set for each area. This multiplier is affected by the risk premium. Since the structural strength of the greenhouse construction was not analyzed here, no effect on the risk premium was revealed.

When the issues mentioned above are examined in detail, it is concluded that greenhouse insurance policies are not evaluated with scientific methods. These policies should be evaluated using scientific methods with software specific to the greenhouse structure. In the current application, greenhouse insurance costs are prepared by independent damage assessment experts trained by TARSİM and affiliated with the Ministry of Treasury. These experts use the software developed by TARSİM. The software they use generates scoring values according to the properties of some building elements in the construction. For example, there is a score corresponding to the profile type and the thickness of the selected profile, which are among the criteria in the software. These scoring values affect the greenhouse policy. In addition, it is seen that the profile intensity used in the roof truss system and the total steel tonnage used in the construction are also subject to scoring. However, there is no calculation of the statics of the greenhouse running in the background of the software. Without any static analysis, it is impossible to make any inferences about the statics of the greenhouse based on these data alone. Because even the location of a profile in greenhouses changes, greenhouse static is affected. At the same time, considering these data, it cannot be concluded that the profile wall thicknesses used are thinner than necessary or thicker than necessary. Without using climatic and geographical data in static calculations, it is impossible to talk about the scientific static strength calculation of a greenhouse built by blacksmiths with a master-apprentice relationship. For this reason, it was concluded that the cost of the insurance policy was created without relying on scientific data. Incorrectly installed greenhouses will harm our country's economy in the long run. In addition, the greenhouse structures in which there are people should be reliable. As a result, only considering the steel tonnage used in the greenhouse is not sufficient to determine whether the greenhouse in question is suitable for sustainable crop production. The fact that the building is built to survive against natural disasters affects the sustainability of production. The purpose of the insurance should not only be to cover the damage, but also to encourage the stabilization of the structure up to certain conditions. If the construction's static and strength adequacy effect is within the scope of the greenhouse insurance, it will also serve for the new greenhouse structures to reach a certain standard.

Features of the Program to be Used to Solve These Problems

An expert simulation program to be prepared in the light of the above data and research will enable scientific calculations regarding the greenhouse structure. It reveals the feasibility analysis of the planned project. Although there are positive developments in our country's informatics field, there is no specific software in compliance with TSE standards regarding the greenhouse issue. This is because the software related to greenhouse structures includes three different disciplines. These disciplines are agriculture, construction, and computer science. It is impossible to create such software without the collaboration of these three different disciplines. The biggest problem that arises can be shown as the fact that the engineers working in the agricultural field do not have sufficient knowledge and equipment in construction and computer software, and the experts in the field of informatics do not have enough knowledge and equipment in agriculture and construction, and the civil engineers on computer software and agriculture. With the result, "Biosystem Engineering", which is newly developing in our country, has been operating on greenhouse automation with the above-mentioned multidisciplinary studies by experts who have been operating in Europe and the USA for many years.

With the software being developed within the scope of the study, it will be possible to project a newly established greenhouse according to scientific criteria by entering the primary data of the greenhouse (width, length, height, angle, province, district, altitude, etc.). The profile thickness values used in the existing greenhouses should be entered in addition to these data. In this way, as a result of the analysis to be made, it will be possible to reach a conclusion whether the greenhouse has a tolerable range value in terms of static. If this band gap is sufficient to meet the geographical and climatic conditions of the region, the policy amount should be reduced. As you move away from these band gap values, the policy amount can be increased. If it is below specific values in terms of static, the strengthening of the greenhouse should be encouraged by not issuing a policy. With this method, it is possible to improve the existing greenhouse stocks. In the current TARSİM system, separate scoring is given to the region's altitude, rainfall amounts such as tornado, snow, and storm. However, the scoring given to the construction system of the loads above alone has no meaning in terms of static strength. It is necessary to calculate by adding all the load components of the construction. The main factor affecting the policy amount in the system should be the dormant account. Factors other than static calculation (cover type and year of use, maintenance and repair order of natural and artificial ventilation and heating systems, plant variety to be grown, etc.) should affect it in small amounts. For sustainable greenhouse cultivation, the most essential requirement is that the greenhouse framework system be stable in an acceptable amount.

While preparing the insurance policy for the greenhouse, the greenhouse building statics should be determined with scientific scales. In this way, expert disputes that may arise later will be prevented. Calculating greenhouse building statics with scientific scales should affect the cost of the policy. The policy costs will lead the manufacturer to construct the correct greenhouse construction and strengthen the greenhouse construction statics if there is an existing greenhouse and if it does not have sufficient building statics. Proper practices will ensure that the greenhouse building stock in our country is made suitable for production. Therefore, it will cause an increase in yield and more sustainable greenhouse cultivation.

CONCLUSIONS

The Agricultural Insurance Pool System operating in our country must use materials with scientific scales. It is necessary to evaluate each greenhouse as a separate project, and even to create an identity similar to the energy consumption identity in the newly implemented buildings in our country. Analyzing the static structure of the greenhouse to be insured using scientific criteria and arranging the greenhouse insurance policy in light of this information will ensure a more accurate valuation.

To add criteria related to the structural statics of the greenhouse to the scope of greenhouse insurance, it is essential to know the components that make up the greenhouse well and install them in accordance with some scientific standards. When calculating the cost of the greenhouse policy, the suitability of the roof type of the greenhouse to be established for the region and altitude, static analysis, construction material, natural ventilation possibilities, flooded wall height and many similar criteria should be reviewed and a greenhouse policy identity should be created. It is certain that the greenhouse construction, which has a high installation cost, will bring a good income when considered long-term. From this point of view, projecting the greenhouse structures to be projected based on scientific criteria will also reduce the operating costs.

It is thought that if these and similar studies are used in the calculation of greenhouse insurance policy costs, the quality of the country's greenhouse building stock will increase over time. With the study, greenhouse structures will reach specific standards and can be classified thanks to the greenhouse identity to be issued. It may be possible to strengthen the existing greenhouses with the same academic study. It is thought that greenhouse cultivation in our country will be more sustainable with the support of TARSİM and private insurance companies for such studies.

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