Journal of Building Engineering 6 (2016) 126–132

Contents lists available at ScienceDirect

Journal of Building Engineering

journal homepage: www.elsevier.com/locate/jobe

Changes of the light transmittance of the LDPE films during the service life for greenhouse application

Nefise Yasemin Emekli [a,*], Kenan Büyüktaş [a], Ali Başçetinçelik [b]

[a] Akdeniz University, Faculty of Agriculture, Department of Agricultural Structures and Irrigation, 07070 Antalya, Turkey
[b] Cukurova University, Faculty of Agriculture, Department of Agricultural Machinery, 07070 Adana, Turkey

ARTICLE INFO

Article history:
Received 12 November 2014
Received in revised form
16 February 2016
Accepted 25 February 2016
Available online 27 February 2016

Keywords:
Greenhouse cover material
Low-density polyethylene films
Transmittance

ABSTRACT

In this study, changes on light transmittance of greenhouse covering materials produced by CO-EX technology with multi-layered CO-EX UV+IR+EVA and UV+IR+EVA+AD additives was investigated during their service life of 24 months. As physical properties, global solar radiation (GSR) and photosynthetically active radiation (PAR) transmittance of greenhouse covering materials were determined. Initial GSR transmittances were determined as 92.7% and 83.6% for UV+IR+EVA and UV+IR+EVA+AD added PE, respectively. The plastic films of UV+IR+EVA and UV+IR+EVA+AD had losses of GSR transmittances of 7.3% and 13.2% at the end of their service life, respectively. These losses were due to accumulation of dust and dirt on the exterior surface of films. Initial PAR transmittance of UV+IR+EVA and UV+IR+EVA+AD films were determined as 80.1% and 83.0%, respectively. Both of the plastic films of UV+IR+EVA and UV+IR+EVA+AD had PAR transmittance losses of 6.2% and 4.9% at the end of their service life, respectively.

1. Introduction

The most important factor affecting plant growth is solar radiation, and the most crucial solar radiation requiring process governing plant growth is photosynthesis. Therefore, the characteristics of greenhouse cladding materials, which can affect the level and quality of the transmitted radiation, are of primary concern for greenhouse cultivation [1]. The most important physical property of the greenhouse cover material may be considered the transmittance (also reflectivity and absorptivity) to three wave bands, i.e. the solar band (200–3000 nm), the photosynthetically active radiation (PAR) band (400–700 nm) and the long wavelength band (> 3000 nm). It is widely accepted that a good covering material should have maximum transmittance in the PAR spectrum and minimum transmittance in the long wave band [2]. The physical properties of the covering material also influence the quality of the indoor microclimate [3]. Greenhouse air temperature, humidity, and leaf temperature, are in turn affected by the light transmittance of the cover material [4]. The radiation transmittance through a covering material is affected by thickness dirtiness, additives (UV, IR, Antifog) and condensate on the interior surface of the material [5].

Overall, the vast majority of the greenhouse area covered by plastic materials is dominated by the use of plastic films made out of polyethylene (PE) [6]. In particular, low-density polyethylene (LDPE) is the most widely used polyethylene grade, due to its relatively good mechanical and optical properties, combined with a competitive market price. Most of these films contain special additives which are designed to either enhance the performance of the film in the special conditions met in a greenhouse or to prolong its lifetime by minimising the effects of the environment on the structure of the films. The advances in the formulation of the LDPE films in use today have led to an expected lifetime of between one and five cultivating seasons. In fact, the expected lifetime is significantly affected by the environmental conditions the film will face during its use. The climate of the region, greenhouse design and microclimate developing inside the greenhouse, use of agrochemicals, and environmental pollution of the area can all severely affect the lifetime of the material by inducing ageing of the plastic film to various degrees. Thus, a film whose lifetime is estimated to be four seasons in North-Central Europe will only last two to three seasons in the Mediterranean region [7].

Characteristic values of total solar transmittance of plastic films (PE) varies between 70% and 95% [2]. Baytroun et al. [8] found that radiation transmittance of different greenhouse covering materials, containing UV, UV+IR and UV+IR+anti-fog additives, ranged from 75% to 80%. Geoola et al. [1] found that solar radiation transmittance of UV, UV+IR and UV+IR+AD added LDPE was 83.6%, 80.5% and 80.4%, respectively. They reported that the loss in

* Corresponding author.
E-mail addresses: nytezcan@akdeniz.edu.tr (N.Y. Emekli), kbuyuktas@akdeniz.edu.tr (K. Büyüktaş), alibcc@gmail.com (A. Başçetinçelik).

http://dx.doi.org/10.1016/j.jobe.2016.02.013
2352-7102/

Fig. 1. The model greenhouses at Akdeniz University Agricultural Faculty Research and Application Field.

Table 1
Climate data for long-term averages of the Antalya (1960–2012) [11].

Months	Mean high temp. (°C)	Mean low temp. (°C)	Mean temp. (°C)	Mean humidity (%)	Mean rainfall (mm)	Daily shiny period (h, min)
Jan	14.9	5.9	9.8	65.5	214.4	5.18
Feb	15.4	6.1	10.3	65.3	155.8	5.49
Mar	17.9	7.9	12.6	66.2	98.0	6.51
Apr	21.2	11.0	16.0	67.6	54.1	8.03
May	25.6	15.0	20.4	66.6	30.5	9.55
Jun	30.9	19.5	25.3	59.3	7.3	11.40
Jul	34.0	22.6	28.3	57.1	2.7	12.04
Aug	33.9	22.4	28.0	59.3	1.8	11.33
Sep	31.0	19.1	24.6	59.1	12.5	10.58
Oct	26.6	15.1	19.9	60.6	70.8	8.05
Nov	21.0	10.5	14.7	64.6	144.1	6.30
Dec	16.5	7.4	11.3	67.0	251.2	5.59

Table 2
Types of plastic films used to cover the experiment.

Code	Type of plastic film
UV+IR+EVA	UV stabilized, infra-red and ethylene vinyl acetate
UV+IR+EVA+AD	UV stabilized, infra-red, ethylene vinyl acetate and anti-drop

solar radiation transmittance of films due to accumulation of dust and dirt reached about 8% after 3 months. Al-Helal IM and Al-hamdan AM [9] investigated degradation of the radiative properties of a 200 μm- polyethylene film (PE) caused by exposure to the harsh environment of Riyadh Saudi Arabia over a period of 13 months They reported that the relative losses of global solar radiation (GSR) and photosynthetically active radiation (PAR) transmittance were 9% and 15.3%, respectively, after three months.

Most LDPE greenhouse films on the market today comprise co-extruded multi-layered films with 4–10% ethylene vinyl acetate (EVA). The addition of EVA imparts superior elasticity, mechanical strength, resistance to ultra-violet (UV) radiation and thermic effect to the films [10]. Currently, greenhouse films are produced by co-extruded technology in Turkey. Co-extruded production technology provides uniformly distribution of the film thickness and the additives used in the production stage into the cover material.

Throughout the world, especially in the Mediterranean regions, greenhouse production is carried out by taking advantage of the favourable climate so performance during the service life of greenhouse covering materials is important. Most of the earlier studies have been carried out on the effects of the light transmittance of cover materials in model greenhouses for a period 3 or 6 months. There is no a study on the light transmittance changes during the service life of cover materials. In this study, changes on light transmittance (global solar radiation and PAR transmittance) of greenhouse covering materials produced by CO-EX technology with CO-EX UV+IR+EVA and CO-EX UV+IR+EVA+AD additives films was investigated during their service life of 24 months.

2. Experimental

2.1. Experimental greenhouse

The experiment was conducted at Akdeniz University Agricultural Faculty Research and Application Field in Antalya Province, Turkey (The research station: latitude 36°54′, longitude 30°38′, altitude 54 m) during the time of 2011–2013 years. The research area has a typical Mediterranean climate: hot and dry summers and mild and rainy winters. Four model arched roof plastic greenhouses which have 20 m^2 (4×5 m)^2 floor area were used. The geometrical characteristics of model greenhouses are as follows: side height of 2.0 m; ridge height of 3.5 m, width of 4 m, length of 5 m, oriented East-West. The frame of the greenhouses was made of steel. Vent openings in the model greenhouses comprised only the roof vent. These vents were open for natural ventilation and the ventilation area was 20% of floor area (Fig. 1).

The greenhouses were cultivated with tomato crop planted in single row. Tomato growing was made during 2 years (2011–2012 and 2012–1013 fall and spring seasons). Fall season is between October and March. Spring season is between March and June.

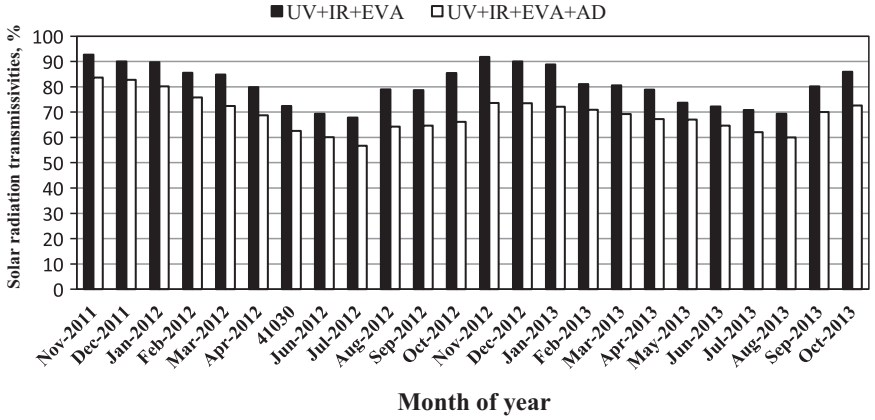

Fig. 2. Solar radiation transmittance of plastic films during the service life.