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Effect of Photoselective Shading Nets on Productivity and Economic Viability in Pepper Crops

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ABSTRACT

In recent years, the use of photoselective shading nets to mitigate the harmful high radiation caused by the increase in temperatures is growing. The objective of this work was to study the positive effects - in terms of yield and profitability of photoselective shade nets in two types of pepper: Lamuyo (cultivars Alcudia and Pompeo) and California (cultivars Bendigo and Cayetano). The weekly yields, classified into different calibre, were analysed over two years, and for the analysis of economic profitability, the Equivalent Annual Value (EAV) was used with an analysis of sensitivity. The yields obtained with the pearl-colored net giving 30% shading were superior to open cultivation (no netting), in all the studied cultivars; in particular, Cayetano and Pompeo had 136 and 86% greater yields, respectively. This same trend was observed for the red-colored net giving 30% shading, with 88 and 74% increase in yield in Cayetano and Pompeo, respectively. In economic terms, the EAV was superior with the use of the pearl net, especially for the cultivars Alcudia and Cayetano - being €14,864 and €13,326 ha^{-1} yr^{-1}, respectively. The yield and profitability were better for the crops grown under the pearl-colored photoselective net, especially for cultivars Alcudia and Cayetano. The sensitivity analysis showed that the probability of obtaining negative returns was higher in the absence of netting, while under the shade nets it was below 10%.

Keywords*:* Equivalent annual value, High solar radiation, Monte Carlo simulation, Net present value.

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INTRODUCTION

Global warming is leading to great challenges for society, in general, and for crop production in particular. In the latter case, the challenge is related to the increase in air temperature and in the intensity of solar radiation.

Sweet pepper is the world's second most important vegetable after tomato. Southeast Spain is among the main production areas of sweet pepper in Europe, with 11,860 ha (MAPA, 2019). Peppers in Southeast Spain are mostly grown in greenhouses, but in recent years, outdoor cultivation has increased, representing an extra-late cycle. Planting takes place in spring, and the cultivation ends in summer. During this period, prolonged high temperatures (35-40°C) occur, as a result of high solar radiation. This can increase the incidence of abiotic disorders in crop plants, which will be exacerbated as the climate changes (López-Marín *et al*., 2013), with deterioration in the cell division, leaf development, and reproductive development (Flaishman *et al*., 2015). Some physiological disorders in fruit, such as sunburn, occur mainly when air temperature and the number of sunshine hours are high during ripening (López-Marín *et al*., 2019a).

Photoselective shading nets provide physical protection against hail, wind, birds,

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and insect-borne diseases (Shahak *et al.*, 2008). Roofing materials make an essential contribution to the productivity of greenhouse crops, enabling the creation of a microclimate in which both temperature and relative humidity are modified. The reduction of the solar radiation transmitted below this type of netting lowers the temperature of the air, as well as the rate of transpiration in the greenhouses. Consequently, the efficiency of water use is increased and the crop productivity rises by up to 40% (Ahemd *et al.*, 2016).

The currently available shading nets are made of different materials, providing different percentages of transmission, absorption, and reflection of light, although most of them are black and poorly photoselective (López-Marin *et al*., 2019a).

In general, studies have focused mainly on the aboveground parts of the plant and have shown that photoselective nets can differentially affect plant vegetative growth, flowering, harvest time (early or late maturation), fruit quality, and yield (Shahak *et al*., 2008). According to the literature, photoselective shading nets improve the quality of pepper fruits (López-Marín *et al*., 2019), significantly increase productivity (Fallik *et al*., 2009), and reduce the infestation of crops by pests and diseases (Díaz-Pérez, 2014). Specifically, in terms of productivity, Shahak *et al.* (2008) obtained higher yields of red pepper with red, yellow, and pearl nets giving 30 or 40% shade, in comparison with black nets providing the same level of shade. This coincides with studies conducted by Fallik *et al*. (2009), where red and yellow shade nets gave significantly higher yields. These results agree with those obtained by Ayala-Tafoya *et al.* (2011) in tomato grown under nets providing 30 or 50% shade. In the Southeastern Mediterranean Basin it has been shown that nets with a shading percentage of 30% give the best results for pepper (López-Marín *et al*., 2019a).

However, there are no studies on the economic profitability of the application of these types of nets in pepper crops. For this reason, and taking into account that the type of cover affects not only the amount of fruit obtained but also its commercial quality, in the present work, the profitability of specific types of pepper under different covers is determined.

For this purpose, here we analyze the hypothesis that the use of photoselective shade nets will give rise to differences in the production, fruit quality (calibre), yield, and revenues of pepper crops, in comparison with cultivation in an open field, and that there will also be differences between the types of net with regard to these parameters.

For this, the income is compared with the costs of each alternative, taking into account that the income depends not only on the average market price of each date considered, but also on the fruit calibres obtained. In order to obtain a correct incorporation of annual costs and the projected multi-year costs, the net present value and the net annualized value are used. Finally, a sensitivity analysis will allow a correct examination of the uncertainty inherent in both income and costs as well as the detection of the probability of loss avoidance. Ultimately, this study is concerned with the determination of the possible economic benefits for growers of enhanced production, based on the use of photoselective nets and taking into consideration the costs involved.

MATERIALS AND METHODS

The trials were carried out on the experimental farm of the IMIDA at Torreblanca, located at 37º 45' N (longitude) and 0º 59' W (latitude), in the Campo de Cartagena area (region of Murcia, Spain). The pepper plants used were of the California type, cultivars 'Bendigo' (Enza Zaden Spain S.L) and 'Cayetano' (Enza Zaden Spain S.L), and of the 'Lamuyo' type, cultivars 'Alcudia' (Semillas Fitó S.A) and Pompeo (Nunhems Spain, S.A). They were grown in single rows 1 m apart, with 40 cm between plants in a given row (plant density of 25,000 plants ha^{-1}). Irrigation was applied based on estimations of the weekly crop evapotranspiration; the surplus water lost by drainage represented more than 20-25% of the irrigation water, to maintain the nutrient balance in the rhizosphere and avoid excessive salinity (del Amor and Gomez-Lopez, 2009). The work was performed over two years: in 2016, the plants were transplanted on April 4th and the crop cycle ended on August 16th, and in 2017, the plants were transplanted on April 7th and the crop cycle ended on August 18th. The trials were conducted following the agricultural practices commonly used in commercial sweet pepper production in this area, in two Kyoto-model tunnel greenhouses. Each unit of cultivation or greenhouse was 5.55 m wide, 18.00 m long, and 2.70 m high in the roof ridge, giving a usable area of 100 m^2. The greenhouses were independent, being 5 m apart. The nettings used were pearl with 30% shading, red (30% shading), and reference (no shading).

The air temperature in each unit was monitored during the growing cycle and was recorded using a Hobo U12 temperature data logger (Onset, Massachusetts, USA). The average temperatures under the pearl 30% and red 30% shading nets, and the reference (without shading), from May to August 18th, are shown in Table 1.

The nets were characterized in terms of the quantity and quality of the transmitted radiation (Table 2). For this purpose, the solar radiation flux spectrum was measured in a total band of 350 to 1,050 nm wavelength (Total solar Radiation: RT), at 1-nm intervals, by means of a BLACK-Comet-SR UV-VIS-NIR spectrometer (StellarNet Inc., USA). Measurements were taken at 12:00 midday (GMT).

Three harvests were carried out in each of the two years of study: On July 11th and 26th and August 16th in the first year, and on July 6th and 21st and August 9th in the second year. The peppers were harvested at their optimum collection time (red color), weighed, and then classified as commercial and non-commercial (sun-affected, tissue rot, etc.). The peppers were also classified into different calibres: Lamuyo, GG (>110 mm), G (90-110 mm), M (70-90 mm), and industrial processing (<70 mm and non-commercial); California, (>90 mm), G (70-90 mm), 70-90, M (60-80 mm), and industrial processing (<60 mm and non-commercial).

Prices

Weekly prices were obtained for the two types of pepper, Lamuyo and California, from the information provided by the Ministry of Water, Agriculture, Livestock, and Fisheries of the Region of Murcia (CARM, 2019). For the 2005-2008 period, the prices are according to the calibre, without average prices, while from 2009 to 2018 only an average price for the commercial fruit is shown, without disaggregation by calibre, together with another average price for the peppers destined for industrial processing. Since the official statistics do not show the prices per calibre, or the information provided is incomplete, an estimate must be made based on the official statistics (López-Marin *et al*., 2019b). Hence, the information was

Table 1. Mean monthly temperatures for the different treatments (ºC).

	No cover (Open field)	Pearl 30%	Red 30%
April	19.5	18.6	18.2
May	21.2	21.8	21.4
June	27.7	26.0	25.5
July	27.4	27.5	26.7
August	28.6	28.7	27.9

Table 2. Characterization of the different treatments studied, the total radiation, and the PAR.

	Total radiation (w m^{-2})	PAR (w m^{-2})
Pearl 30%	469.1	204.8
Red 30%	501.6	217.7
No cover	828.8	370.2

Please define PAR here.

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completed using regression between the calibre prices, and the average market prices were obtained using information provided by local market exchanges and the information on the official web page of the CARM (CARM, 2019).

Profitability

Income. The hectare was considered as the reference unit. The income was obtained for each of the two years as the product of the weekly production of each calibre multiplied by the corresponding weekly price per calibre. The calibres considered were GG, G, M, and industrial for the California-type cultivars. For the Lamuyo cultivars, given that the price information provided by the Ministry does not distinguish between the G and GG calibre, these two were grouped into a single calibre under the denomination "G", and the M and industrial calibre were also considered.

Costs. Like income, the costs were considered per hectare, and they were classified into annual and multiannual costs. Among the multiannual ones were the installation costs of the greenhouse and drip irrigation, which were common to all types of cover and peppers included in this work. In addition, the specific costs of each cover were considered.

The annual costs were divided into variable costs and fixed costs. The former, in turn, was classified into raw materials, labor, and the variable costs of the machinery itself. It must be borne in mind that within this group are the specific costs of each type of seed and the harvest costs, the latter being related to the yield obtained. The fixed costs were divided into machinery costs, the owner's social security payments, and administrative taxes and expenses. All these were common to all the nettings and pepper cultivars used.

Net Present Value (NPV). The NPV of an investment is obtained by updating the net cash flows generated (Brotons, 2014; 2017). For NVP calculation, the income obtained and the expenses generated, both annual and multiannual, are considered. In all cases, the incomes and payments are considered to have occurred at the time the corresponding income or expenses were generated. The useful life considered was 24 years and the financial imputation was considered to vary during the whole useful life. The NPV is calculated as follows:

$$NPV = \sum_{r=0}^{R} \left(C_r - P_r\right) \cdot \left(1+i\right)^{-r} \quad (1)$$

Where, C_r represents the incoming payments received in year r, P_r the outgoing Payments for year r, i the applied discount rate, and R the useful life.

The discount rate applied is risk-free interest plus β times the premium discount, which is the difference between the market yield $E(R_m)$ and the rate free of risk i_{free} (Banco de España, 2018).

The Equivalent Annual Value (EAV) allows us to have a more compressible vision when deciding on one investment or another, because it allows the comparison of investments with different useful lives. The EAV is obtained from the NPV as follows (Welch, 2009; Brotons, 2017):

$$EAV = \frac{NPV \cdot i}{1-\left(1+i\right)^{-R}} \quad (2)$$

Where, NPV is the Net Present Value, i the applied discount rate, and R the useful life of the greenhouse.

Once the results for the different combinations of nets and cultivars were analyzed, a sensitivity analysis was carried out to determine the influence of the variation in the different variables on the final NPV of the investment, rather than just the effect of the variation of the discount rate, as analyzed by Grafiadellis and Mattas (2000). In this regard, Monte Carlo simulation is especially suitable for the study of the effect of different variables on a given variable (Wagner, 1995).

For the purposes of the Monte Carlo simulation, the revenues were obtained from the product of the price and the weekly yield by calibre. Both the prices and the weekly yields were considered as normal variables whose means and deviations were obtained in this work. The annual costs were also considered as normal variables, whose averages were provided by the study and whose standard deviations were obtained according to the information provided by the experts consulted. The interest rate was considered as a variable that followed a normal distribution around the mean obtained in the work, with a standard deviation of 1%. The Excel spreadsheet was used for the calculations and a total of 40,000 iterations were performed. The Value at Risk (VaR) was used for a better understanding of the analysis. Although the VaR was originally designed for use in financial institutions, it´s use is currently spreading in other sectors such as agriculture, as can be seen in the work of Manfredo and Leuthold (1999) and Brotons *et al*. (2018) - who calculated the VaR to quantify the market risk of cattle feeders.

The VaR can be defined as the lowest value of a variable for a certain level of confidence α; that is, the value for which α% of the possible values of said variable are less than said value, and (1-α)% is greater. In this way, it is possible to know the percentage of cases for which the NPV or the EAV is positive (Welch, 2009). Thus, if a high percentage of values (greater than 95% of cases) are positive, we can affirm that there is no risk that the possible modification of the income and expenses will not affect the profitability. In this way, the confidence level α at which NPV= 0 can be obtained as the probability that VPN is less than or equal to zero.

$$NPV_{\alpha} = P(NPV \leq 0) \qquad (3)$$

Statistical Analysis

There were three treatments (two covers and one open field). In each treatment, the experimental design was a randomized block. Each treatment had four cultivars (Alcudia, Bendigo, Cayetano, Pompeo) with four blocks of 10 plants for each one.

The results were analyzed using the IBM SPSS Statistics 25 package. The differences between treatments (P< 0.05) for the different parameters studied were evaluated by analysis of variance (ANOVA), followed by Tukey's test of comparison of means.

RESULTS AND DISCUSSION

Income

Firstly, the existence of price differences among calibres was analyzed. Based on the average prices over 14 years (2005-2018) of the California and Lamuyo peppers (Murica regional office of CARM (2019) and using regressions between the weekly prices by calibre, it was deduced that calibre GG and G had the highest prices. These conclusions are similar to those obtained in a study on tomatoes cultivated under different nettings (López-Marin, 2019b), where there was little price difference between the two largest sizes, the difference being greater with respect to the medium-sized fruits and those destined for industrial processing. The same kind of analysis has been performed by other authors, like Brotons *et al*. (2015), whereas dos Santos *et al.* (2013) used an autoregressive model of means. However, for other products, like physalis fruits (D'angelo *et al.*, 2017), the calibre prices were not important because the revenues depended more on the quantity than on the quality of the fruit. Table 3 shows the total harvested yield (commercial production plus industrial) of the two years of study, for each cultivar and each harvest date (weeks 28, 30, and 33). The weekly analysis has usually been used for this kind of horticultural crop (Heuvelink, 1995). At the first harvest (week 28), the yield was greater in Cayetano plants cultivated under photoselective shading nets than in plants cultivated without shading; the yields under the pearl and red nets were 135 and 147% higher, respectively (Table 3). The total production was 136 and 88% higher with the pearl and red nets, respectively, compared to the open-air

Table 3. Yield of pepper cultivars, by cover type and harvest date (kg ha^{-1}) (Mean±SE).

Type	Cultivar	Harvest (Week)	No cover	Pearl	Red
Lamuyo	Alcudia	1 (28)	12780±1842	19790±400	16825±756
		2 (30)	9620±3674	14488±1136	8366±3901
		3 (33)	13130±857	19583±1667	11648±1429
	Pompeo	1 (28)	7452±1914	10179±773	7774±1956
		2 (30)	7560±2480	14699±680	17726±1442
		3 (33)	10501±1902	22668±274	18967±159
California	Cayetano	1 (28)	10189±338	25188±2548	23955±321
		2 (30)	7257±2065	13633±6433	7249±544
		3 (33)	6256±2350	17004±1084	13459±1346
	Bendigo	1 (28)	11809±519	10298±396	12353±2659
		2 (30)	14522±1403	21118±1047	16655±3926
		3 (33)	12851±4354	15640±5936	9132±1815

cultivation. The cultivar Bendigo, although the same type of pepper, had a different behavior with respect to the nets; it was not so early-yielding under the pearl net, although its total yield was greater than in the open air. With regard to the Lamuyo peppers, cultivar Alcudia was earlier-yielding under both the pearl and red nets than in the open air. In addition, its total yield was greatest under the pearl net. For Pompeo, although its yield under the red net was not so early, its total yield under the pearl and red nets was superior to that in the open air, by 46.3 and 42.6%, respectively. It can be seen that the total yields of cultivars Bendigo and Alcudia under the nets were similar to those achieved in the open air.

For the pepper plants that grew without a shading net, the expected behavior was observed, due to the multiple stresses suffered by the plants. This was similar to the behavior found in other studies of pepper (López-Marín *et al.*, 2012). Thus, in previous work, shading reduced the appearance of tomato cracking and eliminated sun scalds on tomato fruits, thereby increasing the marketable tomato production by about 35% compared to non-shading conditions (Tinyane *et al.*, 2013). For those plants grown under a photoselective shade net, especially for cultivar Cayetano, the increase compared to outdoor cultivation was 136 and 86% under the pearl and red-color nets, respectively. These increases are similar to those (115 to 135%) obtained in pepper by Shahak *et al.* (2008). For cultivars Alcudia and Bendigo, less increments in yield were obtained under the pearl-color net, with respect to outdoor cultivation: 52 and 20%, respectively. These results are in agreement with those of some previous works, such as those presented by Shahak *et al.* (2008), who found that the number of pepper fruits produced per plant throughout the growing season was 30–40% higher, and the yield was 20–30% higher, under these photoselective nets, in all the cultivars tested. However, in these same two cultivars grown under the red-color net, the yields were similar to those obtained without shade cover.

Regarding the existence of differences among the revenues obtained, in € ha^{-1}, for the different cultivars and the different covers, the greatest differences between the crops grown with shading and those grown in the open air were produced for cultivar Cayetano, with increases of 193 and 133% for the pearl and red covers, respectively. In general, the incomes of all the crops grown under cover were superior to those of the respective outdoor crops - even in the

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cultivars Alcudia and Bendigo, with 17 and 6% greater income, respectively, under the red net. This is due to the fact that, although the yield by weight was similar to that obtained in the open air, better calibres of fruits were obtained under the nets (Figure 1).

Costs

The costs and revenue structure of a representative pepper crop in the Southeast of Spain was utilized (López Marín, 2019). The multiannual projection costs considered were the greenhouse, drip irrigation, and cover. The total cost of the greenhouse amounted to € 43,657 ha^{-1} and it has a useful life of 24 years; this includes the earthworks, concrete, structure, enclosure, carpentry, security, and other elements. The installation of the drip irrigation system - with integrated self-compensating drippers in the tubing - cost € 4,600 ha^{-1} and it has a useful life of nine years. The cost of the pearl and red nets was € 23,400 and € 24,375 ha^{-1}, respectively, and their useful life is 10 years. The annual costs are shown in Table 4, with the exception of the seed costs: € 1,550 ha^{-1} for Alcudia, € 2,400 ha^{-1} for Bendigo, € 1,600 ha^{-1} for Cayetano, and € 3,750 ha^{-1} for Pompeo. The harvest costs and the total annual costs are also shown in Table 4. The differences among the covers and cultivars are mainly due to differences in the yield obtained. A similar analysis can be found in Kaur and Sing (2018).

Net Profit

Lastly, the net yield was analyzed for the different covers and varieties in order to determine the differences among them. Once the income and costs have been determined, the NPV can be obtained. A necessary step previous to this is to obtain the discount rate, taken as the sum of the risk-free rate, the 10-year state bond quote (Bank of Spain, 2018), and the risk premium. In this regard, Fernández *et al.* (2011), from a survey of university professors and economic analysts, obtained a risk premium of 5.5% from the

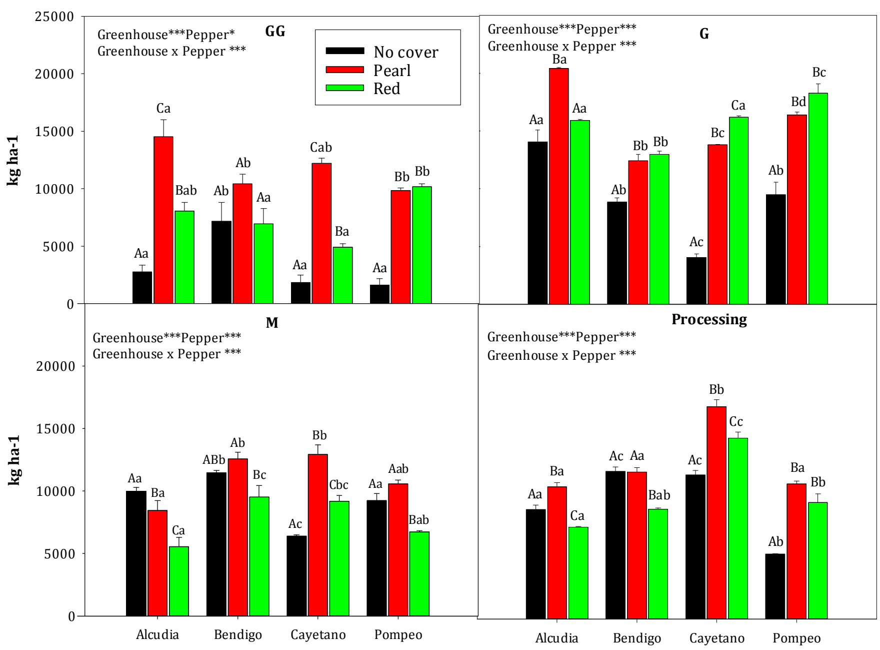

Figure 1. Yield of peppers of calibre GG, G, and M and for industrial processing, by cover and variety. For the same variety (capital letters) and the same cover (small letters), different letters represent significantly different values (Tukey test, P< 0.05).

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Table 4. Comparison annual costs (€ ha^{-1}) for cover type in paper crop.

Concept	No cover	Pearl	Red
1. VARIABLE COSTS	4,825	4,331	4,331
1.1. Raw materials	2,515	2,181	2,181
1.2. Labor	2,060	1,900	1,900
1.3. Variable costs of the machinery	250	250	250
2. Fixed costs	1,270	1,270	1,270
2.1. Machinery	440	440	440
3.1. Social security (Owner)	510	510	510
3.2. Taxes and administrative costs	320	320	320
3. TOTAL COSTS (Without harvest costs)	6,095	5,601	5,601
4. Harvest costs			
Alcudia	1,421	2,154	1,474
Bendigo	1,567	1,882	1,526
Cayetano	948	2,233	1,787
Pompeo	1,020	1,902	1,779

former and of 5.0% from the latter. Therefore, we used the mean value of 5.25%.

The annual cash flows were obtained as the annual income (Table 5) minus the followings:

- annual costs (Table 2),
- aforementioned seed costs (€ 1,550 ha^{-1} for Alcudia, € 2,400 ha^{-1} for Bendigo, € 1,600 ha^{-1} for Cayetano, and € 3,750 ha^{-1} for Pompeo),
- greenhouse installation costs (year 0) of € 43,657,
- drip irrigation installation (€ 4,600 for year 0, and the successive replacements in years 9 and 18),
- cost of the net if applicable (€ 234 for the pearl 30% cover and € 243.75 for the red 30% cover, at the installation time and for the successive replacements in years 10 and 20).

The NPV shows the suitability of the covers for the different cultivars. Note that, in the absence of a cover, cultivars Cayetano and Pompeo had values very close to zero, while the pearl cover produced superior results. Several studies have used NPV to analyze the advantages of several agriculture practices: for instance, Monge-Cordero *et al.* (2013) in pepper, Karandish (2016) in maize, and Carvalho *et al.* (2014) and Lopez-Marin *et al.* (2019b) in tomato, under different covers.

Figure 2 displays the annualized income and expenses. This figure shows how, in the combinations in which the NPV is negative, the income does not cover the costs. Figure 2 can be interpreted as follows: the cultivar Alcudia, when grown without a cover, generated an annualized income of € 15,933 ha^{-1} and the annualized total costs plus the equivalent part of the multiannual projection costs (greenhouse, drip irrigation installation, and nets, if applicable) amounted to € 9,297 ha^{-1}, which represents a positive annual profit of € 6,636 ha^{-1}. This is compatible with the NPV obtained (€ 78,655 ha^{-1}) considering a useful life of 24 years. A similar interpretation can be applied to the rest of the combinations. Note that, for both the pearl and red covers, the annualized income was much higher than the annualized costs, while in the absence of a

Table 5. Annual income per cover and cultivar.

	No cover	Pearl 30%	Red 30%
Alcudia	15.933	26.717	18.705
Bendigo	16.198	20.177	17.089
Cayetano	8.651	25.307	20.173
Pompeo	11.049	21.112	20.327

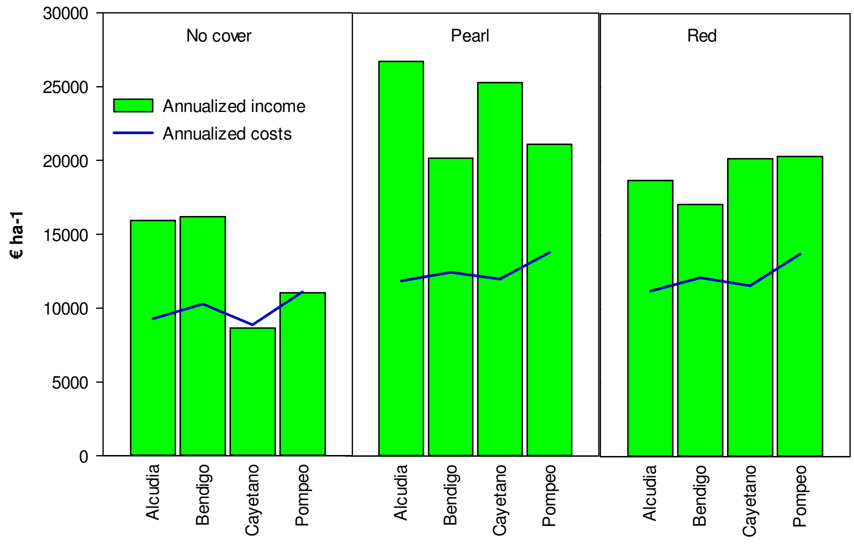

Figure 2. Annualized income and annualized costs.

cover, for Cayetano and Pompeo, the annualized income and annualized costs were very similar.

Sensitivity Analysis

Sensitivity analysis has been used for crops like lettuce (Maestre-Valero *et al.* 2018) and organic tomatoes (Machado-Neto 2018). With respect to income, the prices per calibre were considered as normal variables with the means and standard deviations being those obtained in the corresponding section. Similarly, the yields by calibre were also considered as normal variables, their means and standard deviations being those indicated above. On the other hand, the annual costs were considered as a normal random variable with a mean value of € 5,601 ha^{-1} for the no-cover treatment and € 6,095 ha^{-1} for the pearl and red covers, the standard deviation being € 1,584 ha^{-1} in both cases, in order to include the variability considered as the most likely, by the experts consulted. For the harvest costs, a mean of € 0.04 ha^{-1} and a standard deviation of € 0.007 ha^{-1} were considered. A discount rate of 6.61% was considered, with a standard deviation of 1%. With these data, the variables necessary to obtain the NPV and the EAV were generated. The application of the Monte Carlo model generated 40,000 repetitions, double the number of iterations in the work of López-Marín *et al.* (2017) and a significant increase upon the number of variables considered in the aforementioned analysis. Asci *et al.* (2014) used same methodology to compare tomato production in the greenhouse with that in the open field, and to compare crops in the greenhouse grown with different levels of technology.

Figure 3 shows the probability that the EAV reaches the values shown on the x-axis or lower values: that is, a point on one of these curves with the coordinates (10, 0.6) indicates that the probability that the EAV is less than or equal to € 10,000 is 0.6. A very interesting application of this is the determination of the probability that the EAV is negative, since only those combinations in which the aforementioned probability is low will be interesting.

- The probability of obtaining negative returns is highest with “No Cover” in all cases, especially for Cayetano (0.86) and Pompeo (0.74).
- The probability of obtaining negative EAV values is lowest with the pearl cover, in all cases, being especially so

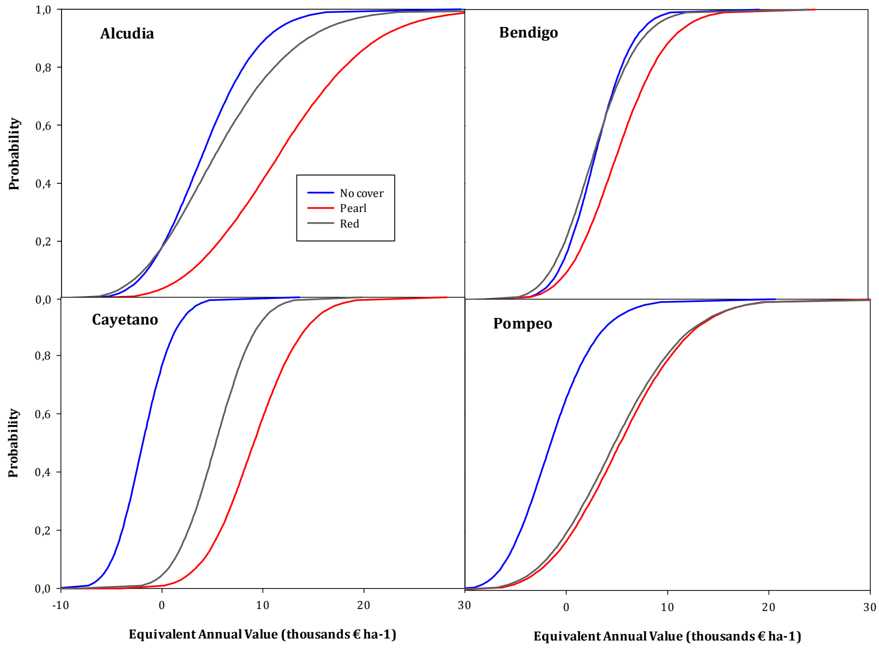

Figure 3. Function of the cumulative distribution of the equivalent annual value.

for Cayetano (0.04) and Alcudia (0.08) and somewhat higher for Bendigo (0.21) and Pompeo (0.27).

- Finally, the red cover occupies an intermediate position, oscillating between the values of 0.13, for Cayetano, and 0.36, for Bendigo.

CONCLUSIONS

The evolution of the prices of the distinct calibre shows that the calibre GG and G had significantly higher prices. Throughout the season, the prices of all the calibres had a downward trend, except that of the peppers destined for processing, which remained stable. For all cultivars, the production of calibre G and GG was greater under shade nets. The yield was earliest for Cayetano grown under shade nets. The yield and profitability were better for the cultivars grown under the pearl-color photoselective net, especially Alcudia and Cayetano. The revenues were also higher for the crops grown under nets and, in cases where the yields were similar, the revenues were higher for these crops due to the greater production of larger fruit. The use of shade nets gave better profitability for all the cultivars studied, in particular for Cayetano. The productivity under the nets did not differ between the two types of pepper studied - Lamuyo and California - but it was affected by differences in genotype and radiation sensitivity among the cultivars. The AEV, the difference between the annualized income and expenses, was highest for Alcudia and Cayetano under the pearl cover. The AEV was much lower for the open-air cultivation, especially for Cayetano and Pompeo, with values close to zero. Finally, the sensitivity analysis shows that the probability of obtaining negative returns was higher in the absence of netting, and was not significant at the 10% level under the pearl net for Cayetano and Alcudia.

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اثر تورهای سایبانی نورگزینشی روی تولید و دوام اقتصادی گیاه فلفل

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چکیده

در سال های اخیر،استفاده از تورهای سایبانی نورگزینشی (photoselective) برای کاهش صدمات تشعشعات نوری زیاد در اثر افزایش گرما در حال گسترش است.هدف این پژوهش بررسی اثرات مثبت تورهای سایبانی نورگزینشی از نظرعملکرد و سودمندی در دو نوع فلفل به نام های *Lamuyoo* (کولتیوارهای (Alcudia and Pompe) و California (کولتیوارهای Bendigo و Cayetano) بود. به این منظور، عملکرد هفتگی فلفل همراه با دسته بندی محصول در کالیبرهای مختلف در طی دو سال مورد تجزیه و تحلیل قرار گرفت و برای تحلیل اقتصادی از شاخص ارزش سالانه معادل (Equivalent Annual Value (EAV) همراه با تحلیل حساسیت استفاده شد. در همه کولتیوارهای مطالعه شده، عملکردهای به دست آمده با سایبان مروارید رنگ که30٪ سایه انداز داشت نسبت به کشت بدون سایه انداز برتری داشت، به ویژه در مورد Cayetano و Pompe که به ترتیب 136٪ و86٪ عملکرد بیشتری داشتند. همین روند در مورد سایبان قرمز رنگ با 30٪ سایه انداز نیز مشاهده شد که در آن عملکرد Cayetano و Pompe به ترتیب 88٪ 74٪ افزایش داشت. از نظر اقتصادی، مقدارEAV در مورد تورهای مروارید رنگ بیشتر بود، به ویژه برای کولتیوارهای Alcudia وCayetano که به ترتیب برابر 14864 و 13326 یورو در هکتار در سال بود. عملکرد و سودمندی برای گیاهانی که در زیر تورهای سایبانی نورگزینشی مروارید رنگ بودند بیشتر بود، به ویژه برای کولتیوارهای Alcudia و Cayetano. تحلیل حساسیت نشان داد که احتمال به دست آوردن بازده منفی در غیاب این تورها بیشتر بود در حالیکه در زیر سایبان مزبور احتمال آن 10 ٪ بود.