

Effect of fruit thinning on fruit yield and quality of cactus pear *Opuntia ficus-indica* (L.) Mill. in a semi-arid area

Mohamed Arba ^{1,*} and Siham Farhat ²

¹ Plant ecophysiology and cultures of arid zones laboratory, Hassan II Institute of Agronomy and Veterinary Medicine, Horticultural Complex of Agadir, Morocco.

² National Office of Food Products Safety and Health (ONSSA), Sidi Slimane, Morocco.

Abstract

The aim of this work was to study the effect of fruit thinning on fruit yield and quality of cactus pear. To meet this objective, trials on fruit thinning were conducted on an adult plantation of cactus pear in a semi-arid region in southern Morocco. The fruit thinning consisted of reducing the fruit load of overcharged cladodes by reducing the number of fruits to 6 or 12 per cladode. It was practiced in early May on three types of one-year old cladodes (small cladodes, the medium ones and large cladodes), by removing some floral buds or young fruits at the flowering stage. The control cladodes had an average number of 18 fruits per cladode. Obtained results showed that the reduction in the load of cladodes improved fruit size and quality. In thinned plants to 6 fruits per cladode and for the three types of cladodes, average fruit weight was 160.44 g and average fruit length and diameter was 8.64 and 6.38 cm respectively. While in not thinned plants and for the three types of cladodes, average fruit weight was only 74.53 g and average fruit length and diameter was 6.40 and 4.46 cm respectively. Fruit thinning increased the content of sugar in the fruits and decreased the number of seeds in the fruits and the fruit peel thickness, but did not affect the juice content in the fruits and the pH and titratable acidity of the juice. Fruit thinning also improved the economic income of the yield and the gain in the yield of thinned plants to 6 fruits per cladode was 33912 DH per hectare compared to not thinned plants.

Keywords: Cactus Pear; Fruit Thinning; Fruit Quality; Fruit Yield; Economic Income

1. Introduction

Opuntias are typical species that are perfectly suited to the development of arid and semi-arid regions thanks to their adaptation to drought and their use in human and animal nutrition. Their culture is not very demanding in water and investments and the income they can generate is important. Cactus pear is considered one of the pillars of the local economy of the arid and semi-arid regions. In the southern Mediterranean countries, as in Morocco, the most plantations of cactus pear are traditional and don't benefit from cultivation practices. The yield is low and the fruits are often of small size and low quality (not very juicy and tasty). However, cultivation techniques which can improve fruit quality, mainly fruit thinning by reducing the fruit load of cladodes, are the practices which are decisive in the marketing of the crop yield. What will improve the market value of the crop and the economic income of the farmers and rural populations of the arid and semi-arid regions. The aim of this work was to study the effect of fruit thinning on the improvement of fruit yield and quality of cactus pear and to evaluate the economic income of this thinning operation for the farmers.

* Corresponding author: Mohamed Arba

Plant ecophysiology and cultures of arid zones laboratory, Hassan II Institute of Agronomy and Veterinary Medicine, Horticultural Complex of Agadir, Morocco.

Several authors reported that the improvement of fruit yield and quality of cactus pear requires appropriate technical management of the orchard, especially the fruit load of cladodes and parameters related to the fruit, such as fruit size, the edible fresh matter content and the organoleptic components of the fruit [1, 2, 3, 4, 5]. A fruit size of 120 g weight is a positive attribute for the marketing of cactus pear fruits. The seed content in the fruit and the fruit peel thickness also have an impact on the marketing of fruits [6, 7]. Cactus pear fruits can be of good quality when they have criteria which are requested by the producer and the consumer, such as fruit size, taste (flavor and sugar content or °Brix > 15) and edible fresh matter [8]. The selling price of the fruits on the local market could be interesting by improving fruit quality using cultivation practices, mainly fruit thinning [5, 9]. Several authors also reported that fruit size of cactus pear depends on the cultivar, water availability, plant mineral nutrition and fruit load of the cladodes [10, 11, 12, 13, 14].

Most of emitted flowers by cactus pear are transformed into fruits, and in a year of high production, the cladodes are too heavy and if this load is not reduced by thinning, the fruits are of small size and the cladodes can be damaged [15]. In cactus pear, the emission of floral buds is often done on one year old cladodes, on the upper half part of the cladodes. Terminal and peripheral cladodes on the plant are the most fertile because they are well exposed to the sun [11, 16, 17, 18, 19]. In a year of high production, a cladode can produce 25 to 40 fruits [20], what leads to the reduction in fruit growth and low fruit quality, and a late and irregular fruit ripening [11, 17]. And in order to produce homogeneous good fruit size, it is necessary to reduce the fruit load of cladodes [16]. However, a severe thinning of 4 fruits per cladode can greatly reduce the yield up to 58% and can even lead to a second flowering or reflowering [14]. Fruit thinning can be practiced manually using gloves that protect against spines and glochids and the appropriate period for thinning is located between two weeks before flowering until three weeks after flowering or two weeks after fruit set. Early bud thinning is difficult to achieve and late thinning does not improve fruit size [11, 21]. Blanco-Macías et al. [22] reported that determining the optimal number of fruits to be removed per cladode depends on the surface of the cladode and its fruit load. On an adult plantation of 335 plants per hectare, a thinning of 6 fruits per cladode yielded 20 tons per hectare and yielded fruits have an average size of 100-120 g [23]. Several studies have shown that leaving a load of 6, 9 or 15 fruits per cladode, the fruit and pulp fresh weight increases as the number of removed fruits per cladode increases [11, 24].

2. Material and methods

Trials were carried out on an adult plantation of cactus pear *Opuntia ficus-indica* (L.) Mill. cv 'Aissa' 19 years old at the experimental station of the Hassan II Institute of Agronomy and Veterinary Medicine in Agadir area, latitude 30 ° 22 'North, longitude 9 ° 39 West and altitude 32 m. Plants have an average length of 2 m and average width of 1.6 m. The planting density is 3 m between rows and 2 m between plants in the rows, i.e. 1666 plants/ha. The soil of the parcel is a moderate alkaline soil with a pH of around 8.4 and electrical conductivity of 0.16 mmhos/cm. It has a sandy-silty texture and an apparent density of 1.4 g/cm³. It is composed of 4.5% coarse sand, 30.3% fine sand, 28.3% coarse silt, 21.3% fine silt and 15.6% clay. The site of trials is characterized by a semi-arid climate with hot and dry summer and mild and relatively wet winter. The annual rainfall is 207 mm. The mean annual temperature is 22°C, the annual maximum is 31°C and the minimum is 12.5°C.

This research work consisted in studying the effect of fruit thinning on fruit yield and quality of an adult plantation under the natural conditions of the environment of the site of trials. Two types of fruit thinning were used: light thinning with 12 fruits per cladode and severe thinning with 6 fruits per cladode. The not thinned plants (control) had an average load of 18 fruits per cladode. Fruit thinning was practiced on three types of one year old cladodes: small cladodes with an area of 509-735 cm², medium cladodes with an area of 736-920 cm² and large cladodes with an area of more than 920 cm². The area of the cladode is determined according to Martin et al. [25]:

$$S = (w / 2) \times (L / 2) \times \pi$$

- S: cladode area
- W: cladode width
- L: cladode length
- $\pi = 3.14$

The experimental design adopted was a randomized block design with 4 blocks. An experimental unit consisted of two plants and studied factors focused on:

- The fruit thinning at the stage of 82% open flowers on one year old cladodes. Fruit thinning was carried out on May 01, 2019. Fruit thinning treatments used were: T: not thinned plants (the control); T1: thinned plants to 6 fruits per cladode; and T2: thinned plants to 12 fruits per cladode.
- Type of thinned cladodes: three types of thinned cladodes according to their surface were used in the study: C1: small cladodes with an area of 509-735 cm², C2: medium cladodes with an area of 736-920 cm² and C3: large cladodes with an area of more than 920 cm².

For each type of cladodes, four cladodes were randomly chosen from the four orientations of the plant (north, south, east, and west). Studied parameters focused on:

- The fruit quality: fruit size (fruit weight and dimensions: fruit length and diameter) and the organoleptic compounds in the fruits (juice and sugar content and titratable acidity and the pH of juice). Fruit quality parameters were carried out on a sample of 24 mature fruits per type of cladodes and per experimental unit. Fruit length and diameter and fruit peel thickness were measured with a caliper. Fruit and pulp weight was measured using an electronic balance with an accuracy of 0.01 g. The content of juice in the fruits was determined according to the formula:

$$\% \text{ in juice} = (\text{juice weight} / \text{pulp weight}) \times 100$$

And the content of sugars in the fruits or degree Brix was measured with a refractometer. The pH of juice was determined with a pH meter and the titratable acidity was carried out by the titration of the juice using NaOH 0,1 N and phenolphthalein as indicator of color change. It is calculated according to IFU [26]:

$$\text{QAC} = 0.64 \times V_{\text{NaOH}}$$

QAC: the titratable acidity expressed in g of citric acid per liter of juice

VNaOH: the volume of NaOH used in the titration (in ml)

For each studied organoleptic parameter, measures were repeated 3 times and the mean value of the three measures was taken into account.

- Fruit yield: it was measured on the two plants of each experimental unit and fruit yield per hectare was calculated on the basis of the density of plantation and average yield per plant.
- Fruit maturation: The monitoring of fruit maturation began after fruit set on a sample of 4 cladodes per plant of each experimental unit and for each type of cladodes C1, C2 and C3 of thinned and not thinned plants, and observations were made with a rate of one week to ten days. The fruit ripening period is the period which extends from the date of 5% mature fruits until the date of 100% ripening fruit and the date of full ripening fruit corresponds to 50% of mature fruits [27]. Fruits reached the stage of maturity when the color of the fruit peel changes from green to yellowish-green. The number of ripe fruits is determined by counting mature fruits in relation to the total number of the fruits. The % of mature fruits is determined according to Oelofse et al. [28]:

$$\% \text{ fruits at ripening stage} = \text{number of fruits at ripening stage} / \text{total number of fruits on the plant} \times 100$$

- The seed content in the fruit: on the samples of fruits used in the study of the fruit quality, 10 g of pulp per fruit were used for the separation of the seeds from the pulp and their subsequent counting.
- The fruit peel thickness: it is measured on the fruit peel using a caliper after peeling the mature fruits.
- The economic income of the thinning operation: it was determined by calculating the gain of the economic income of the yield of thinned plants compared to the yield of not thinned plants, based on the yield, the quality of the fruits and the selling prices of the fruits in the local market.

Plant protection of the parcel of trials against the cochineal carmine *Dactylopius opuntia*:

Cactus pear plays an important socio-economic role in Morocco where it is considered one of the pillars of the economy of the arid and semi-arid zones of the country. The development of its cultivation has been the focus of the Morocco Green Plan which is a national agricultural development program for the period 2010-2020. However, in the recent years this culture has experienced an unprecedented infestation of the carmine cochineal which is a specific pest of

cactus pear. The Ministry of Agriculture has taken measures to deal with this pest by the implementation of measures to fight this scourge, but the expected result is not achieved and several plantations are infested. The revival of this culture in Morocco and its development through the selection and introduction of resistant varieties to cochineal carmine is part of the priorities of the new agricultural development program "Generation Green" for the period 2020-2030.

Plant protection of the parcel of trials against this pest was carried out with chemical treatment at a frequency of at least once a month during the period of experiments. Five treatments were carried out with an insecticide called 'Durban 4' for his trade name. The active material of the insecticide is chlorpyrifos-ethyl with a concentration of 480 g/l; this active matter belongs to the organophosphate organochlorine chemical family. The dose used of the commercial product for plant treatment was 150 cc/hl. The product is used for two purposes: preventive treatment for non-infested plants and curative for infested plants to eradicate the pest from the plants. Cactus pear plants are completely wet by the porridge of the product in order to ensure better effectiveness of the product during the treatment.

3. Results and discussion

3.1. Effect of fruit thinning and the type of cladodes on fruit yield and quality

3.1.1. Effect of fruit thinning and the type of cladodes on fruit yield

Table 1 presents the mean fruit yield per plant and per hectare of thinned and not thinned plants. Fruit yield per hectare was determined on the basis of the planting density used in the parcel of trials (1666 plants/ha) and average fruit yield per plant. Fruit thinning had a significant effect ($p < 0.001$) on fruit yield of cactus pear *O. ficus-indica*. Thinned plants to 12 fruits per cladode gave the highest yield of 42.15 kg/plant, an increase of 2.91 kg/plant or 7.41% compared to not thinned plants and 12.62 kg/plant or 42.7% compared to thinned plants to 6 fruits per cladode. Several authors also reported that the improvement of fruit yield requires appropriate management of the fruit load on the cladodes (Sulé et al., 2002; Ochoa, 2003; Barbara, 2007; Mora et al., 2011; Migliore et al., 2015; Timpanaro et al., 2015).

Table 1 Effect of fruit thinning on fruit yield of cactus pear *Opuntia ficus-indica* in Agadir area

Fruit thinning treatments	Fruit yield	
	Mean fruit yield per plant (kg)	Mean fruit yield per hectare (t)
T1	29.53 c	49.19
T2	42.15 a	70.22
T	39.24 b	65.37

a, b, c: Comparison groups according to Tukey test (confidence level of 95%).

3.1.2. Effect of fruit thinning and the type of cladodes on fruit size

Obtained results showed that for fruit size (fruit weight and fruit length and diameter) there was a significant difference ($p \leq 0.001$) between fruit thinning treatments, the type of cladodes and the interaction of the two factors. The thinning treatment T1 (thinned plants to 6 fruits per cladode) gave the highest fruit weight and fruit length and diameter for the three types of cladodes (small cladodes, the mediums and large cladodes) with an average fruit length and diameter of 8.64 and 6.33 cm respectively and average fruit and pulp weight of 160.44 and 99.86 g respectively. While in not thinned plants, average fruit length and diameter for the three types of cladodes was 6.40 and 4.66 cm respectively and average fruit and pulp weight was only 74.53 and 48.42 g respectively. The T1/C3 combination of thinned plants to 6 fruits per cladode and large cladodes yielded fruits with the largest size (fruit and pulp weight of 180.50 and 112.92 g respectively and fruit length and diameter of 9.25 and 6.71 cm respectively) (Table 2). This has shown that the large severe thinned cladodes have yielded fruits with the largest size due to the low fruit load of the cladodes and large photosynthetic surface of the C3 cladodes. Our results are similar to those of several authors who reported that fruit and pulp weight increase with the increase of the number of removed fruits per cladode (Inglese et al., 1995; Zegbe Dominguez et al., 2009) and a thinning of 6 fruits per cladode yielded good size fruits with 100-120 g in fruit weight (Inglese et al., 2002). Several authors also indicated that obtaining homogeneous and good size fruits requires reducing the cladodes load of loaded cladodes (Inglese et al., 1994) and improving fruit quality requires appropriate management of the fruit load of the cladodes (Sulé et al., 2002; Ochoa, 2003; Barbara, 2007; De Wit et al., 2010; Mora et al., 2011; Migliore et al., 2015; Timpanaro et al., 2015). Other authors reported that fruit size of cactus pear depends on the fruit load of the cladodes (Inglese et al., 1995; Ochoa et al., 2002; Potgiter, 2007; Zegbe Dominguez & Mena Covarrubias, 2010) and loaded

cladodes reduce fruit quality (Inglese et al., 1995; Nerd & Mizrahi, 1997). Some other authors indicated that the determination of the number of fruits to be removed per cladode depends on the surface of the cladode and its fruit load (Blanco-Macias et al., 2006), and when loaded cladodes are not thinned the fruits are of small size and the cladodes can be damaged (De la Barrera & Nobel, 2004; FAO, 2018).

Table 2 Effect of fruit thinning and the type of cladodes on fruit and pulp weight and fruit length and diameter of cactus pear *O. ficus-indica* in Agadir area

Fruit thinning treatment	Fruit length (cm)				Fruit diameter (cm)			
	C1	C2	C3	Mean value	C1	C2	C3	Mean value
T1	8.17 c	8.52 b	9.25 a	8.64	6.10 c	6.34 b	6.71 a	6.38
T2	6.92 f	7.47 d	8.06 c	7.48	5.30 e	5.61 d	5.92 c	5.61
T	5.62 h	6.40 g	7.20 e	6.40	4.26 h	4.70 g	5.03 f	4.66
Mean value	6.90	7.46	8.17	Mean value	5.22	5.55	5.88	
	Fresh fruit weight (g)			Mean value	Fresh pulp weight (g)			Mean value
T1	138.71 c	162.12 b	180.50 a	160.44	85.56 c	101.10 b	112.92 a	99.86
T2	90.93 f	123.58 d	139.71 c	118.07	55.00 f	76.18 d	86.94 c	73.35
T	53.22 h	72.06 g	98.31 e	74.53	33.23 h	45.43 g	61.62 e	48.42
Mean value	94.29	119.25	139.50	Mean value	58.60	74.24	88.82	

a, b, c, d, e, f, g, h: Comparison groups according to Tukey test (confidence level of 95%).

3.1.3. Effect of fruit thinning and the type of cladodes on the content of organoleptic compounds in the fruits

Fruit thinning and the type of cladodes and the interaction of the two factors have no significant effect ($p > 0.05$) on the juice content in the fruits and the pH and titratable acidity of the juice. The type of cladodes and the interaction of the two factors also have no significant effect ($p > 0.05$) on the sugar content in the fruits. However, fruit thinning had a significant effect ($p \leq 0.001$) on the sugar content in the fruits. Fruits of the thinned plants T1 (6 fruits per cladode) gave the highest sugar content in the fruits of the three types of cladodes (16.24 °Brix), followed by the fruits of the thinned plants T2 (12 fruits per cladode) with 14.97 °Brix for the three types of cladodes and the fruits of not thinned plants gave the lowest sugar content of 12.16 °Brix in the fruits of the three types of cladodes (Table 3). Several authors also reported that the reduction in the number of fruits in loaded cladodes improves the quality of the fruits (Sulé et al., 2002; Ochoa, 2003; Barbara, 2007; De Wit et al., 2010; Mora et al., 2011; Migliore et al., 2015; Timpanaro et al., 2015).

Table 3 Effect of fruit thinning and the type of cladodes on the juice and sugar content in the fruits and the pH and titratable acidity of the juice of cactus pear *O. ficus-indica* in Agadir area

Fruit thinning treatments	pH of the juice				Juice content in the fruits (%)			
	C1	C2	C3	Mean value	C1	C2	C3	Mean value
T1	6.61 a	6.40 a	6.54 a	6.51	56.72 a	57.84 a	54.63 a	57.39
T2	6.55 a	6.45 a	6.62 a	6.54	56.13 a	52.69 a	57.63 a	55.48
T	6.46 a	6.57 a	6.44 a	6.49	58.42 a	55.59 a	55.42 a	56.47
Mean value	6.54	6.47	6.53	Mean value	57.09	55.37	56.89	
	Titratable acidity of the juice (g/l)			Mean value	Sugar content in the fruits (°Brix)			
T1	0.31 a	0.35 a	0.28 a	0.31	16.24 a			
T2	0.36 a	0.28 a	0.34 a	0.32	14.97 b			
T	0.29 a	0.30 a	0.30 a	0.29	12.16 c			
Mean value	0.32	0.31	0.30					

a, b, c: Comparison groups according to Tukey test (confidence level of 95%).

3.1.4. Effect of fruit thinning and the type of cladodes on the seed content in the fruits and fruit peel thickness

Fruit thinning also had a significant effect ($p \leq 0.001$) on the seed content in the fruits. The average number of seeds in the fruits of not thinned plants was 53 per 10 g pulp, while average number of seeds in the fruits of thinned plants was 42 and 36 per 10 g pulp respectively for thinned cladodes to 12 fruits and thinned ones to 6 fruits, a decrease of 14.27% compared to thinned plants to 12 fruits per cladode and 32.13% compared to thinned plants to 6 fruits per cladode. However, the type of cladodes and the interaction of the two factors have no significant effect ($p > 0.05$) on the seed content in the fruits (Table 4). Fruit thinning and the type of cladodes, and the interaction of the two factors have a significant effect ($p \leq 0.001$) on the fruit peel thickness. The mean fruit thickness of not thinned plants was the highest with 4.99 mm for the three types of cladodes, followed by the fruit peel thickness of thinned plants to 12 fruits per cladode with 4.61 mm for the three types of cladodes and the peel fruit thickness of thinned plants to 6 fruits per cladode was the lowest with 4.13 mm for the three types of cladodes. The best result was obtained with the C1/T3 combination with a mean fruit peel thickness of 3.89 mm (Table 4). Several authors also reported that fruit thinning in cactus pear reduces the content of seeds in the fruits and the fruit peel thickness (Mokoboki et al., 2009; FIA, 2010). Some other authors indicated that the reduction in the number of fruits in loaded cladodes improves the quality of the fruits (Sulé et al., 2002; Ochoa, 2003; Barbara, 2007; De Wit et al., 2010; Mora et al., 2011; Migliore et al., 2015; Timpanaro et al., 2015).

Table 4 Effect of fruit thinning and the type of cladodes on the seed content in the fruits and the fruit peel thickness of cactus pear *O. ficus-indica* in Agadir area

Fruit thinning treatments	Types of cladodes according to their surface							
	C1	C2	C3	Mean value	C1	C2	C3	Mean value
	Number of seeds per 10 g pulp				The fruit peel thickness (mm)			
T1	36.12 a	36.08 a	35.5 a	35.90	4.36 e	4.15 f	3.89 g	4.13
T2	41.75 b	42.25 b	41.63 b	41.88	4.86 b	4.58 d	4.39 e	4.61
T	53.75 c	52.46 c	52.50 c	52.9	5.19 a	5.01 b	4.76 c	4.99
Mean value	43.87	43.60	43.21	Mean value	4.80	4.58	4.35	

a, b, c, d, e, f, g: Comparison groups according to Tukey test (confidence level of 95%).

3.2. Effect of fruit thinning and the type of cladodes on the fruit maturation

Figure 1 shows the evolution of the percentage of rip fruit on the three types of cladodes in thinned and not thinned plants of cactus pear. Fruit thinning and the type of cladodes have a significant effect ($p \leq 0.001$) on fruit maturation. Fruits of the plants T1 reached the end of maturation (100% mature fruits) on 07/19/2019, fruits of the plants T2 reached the end of maturation 2 days after the end of fruit maturation of the plants T1 and the fruits of not thinned plants T reached the end of maturation on 07/26/2019, a delay of 7 days compared to plants T1. The thinned plants have therefore shown an early maturation of 5 to 7 days compared to not thinned plants. Research works carried out in this way in some countries have shown that fruit thinning has a positive effect on the early and regular ripening of the fruits (Inglese et al., 1995 and 2002). Fruits of the large cladodes C3 have shown an early 2 days compared to fruits of the cladodes C2 and more than 3 days compared to fruits of the cladodes C1. Fruits of the cladodes C3 reached the end of maturation 46 days from the start of maturation, followed by the fruits of the cladodes C2 which took 48 days to reach the end of maturation and fruit maturation of the cladodes C1 took 49 days after the start of maturation. Several authors also reported that loaded cladodes lead to late and irregular fruit maturation (Inglese et al., 1995; Nerd & Mizrahi, 1997).

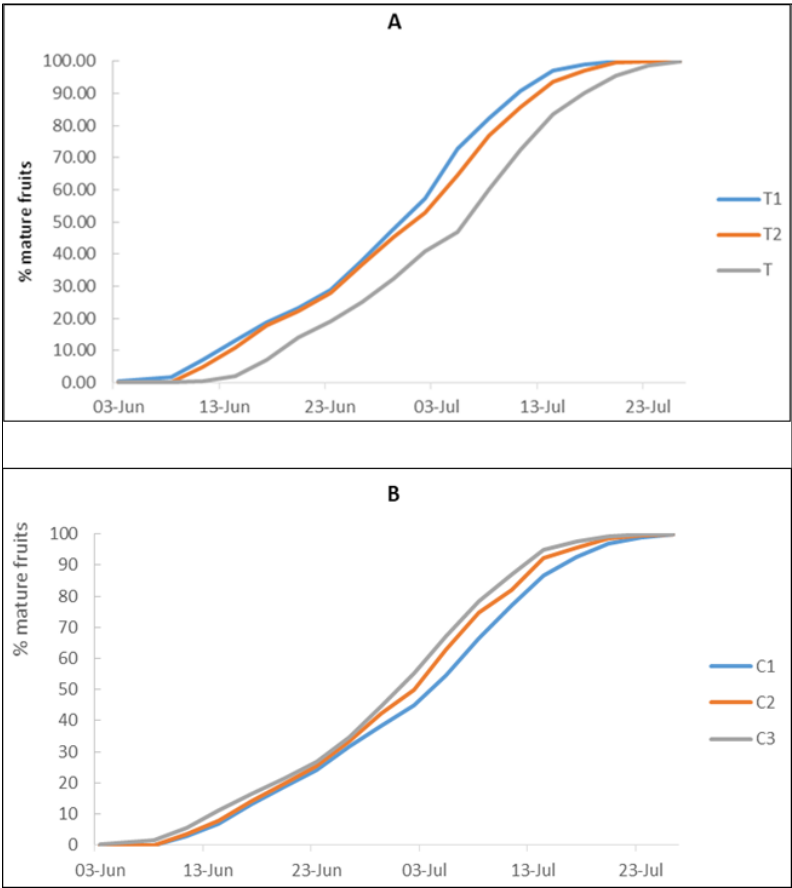


Figure 1 Evolution of the percentage of mature fruits in thinned and not thinned plants (A) and the three types of cladodes (B) of cactus pear *O. ficus-indica* in Agadir area

3.3. The economic income of the fruit thinning operation

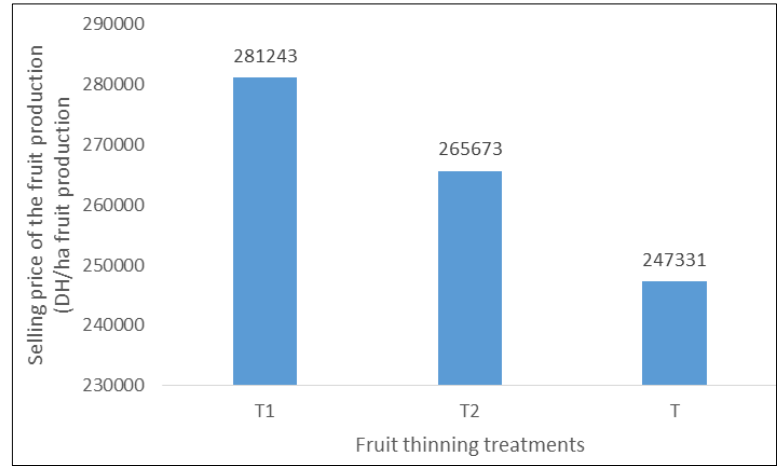


Figure 2 Selling price of the fruit production of 1 hectare thinned plants and not thinned plants of cactus pear *Opuntia ficus-indica* in Agadir area

The selling price of cactus pear fruits on the market depends essentially on the yield and fruit quality and the economic income of the yield for the farmer depends on the quality of the fruits and the selling price of the fruits on the local market. The purpose of studying the economic income of the thinning operation is to assess its impact on the gain to be made compared to not thinned plants. The production yield per hectare was determined on the basis of the mean fruit yield per plant of each thinning treatment and the planting density used in the parcel of trials (1666 plants per hectare) (Table 1). The selling price of the production is determined on the basis of the production yield of each thinning

treatment and the mean selling price of one kilogram of each fruit size during the fruit harvest season in Morocco (early July-mid August). The mean selling price of the fruits in the 2019 year was 5.71 DH/kg for large size fruits (fruit weight > 120 g) (fruits of the plants T1) and 3.75 DH/kg for small and medium size fruits (fruit weight < 120 g) (fruits of the plants T and T2). The selling price of 1 hectare fruit yield of thinned and not thinned plants for the 2019 year is presented in Figure 2. The highest selling price was obtained with the plants T1, with a mean value of 281242 DH/ha. It exceeded the selling price of the fruit production of the plants T2 with 15570 DH/ha and the selling price of the fruit yield of not thinned plants with 33912 DH/ha. This has shown that the thinning operation increases the economic income of the production yield by increasing the gain of production compared to not thinned plants, although the fruit production of thinned plants was lower than that of not thinned plants, but the selling prices of the production of thinned plants were higher than the selling prices of the production of not thinned plants thanks to good size of the fruits of thinned plants. Our results are similar to those of several authors who reported that the fruits of thinned plants, which are of good size and good quality (good sugar content, low seed content and thin fruit peel), improve the marketing of the fruit production and the market value of the fruits (Makoboki et al., 2009; FIA, 2010).

4. Conclusion

Fruit thinning has improved the quality of the fruits, mainly fruit size and the sugar content in the fruits. What improves the selling price of the fruit production on the market and the rentability of farmers and rural populations in the arid and semi-arid regions, despite the negative effect of the thinning operation on fruit yield. Fruit thinning also made it possible to obtain an earlier and more regular ripening of the fruits in time, mainly on large cladodes, and to avoid the alternation of the production by reducing the number of fruits on loaded cladodes. The best results in terms of fruit size and quality were obtained in thinned plants to 6 fruits per cladode. And this has increased the gain of the fruit production of thinned plants by increasing its economic income compared to the production of not thinned plants thanks to attractive selling prices of the good size fruits of thinned plants on the market. The fruit thinning operation in cactus pear is a cultural practice which is easy to achieve and economically not expensive because it can be practiced by the farmers and their family members without calling to specialized workforce. It can be therefore considered as a cultural operation which is within the reach of farmers and rural populations of the arid and semi-arid regions and which can improve their income by the benefit they gain in practicing this operation.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no conflicts of interests to declare.

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