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Effect of removing the spring flush and irrigation on the reflowering and late ripening of cactus pear *Opuntia ficus-indica* (L.) Mill.

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Effect of removing the spring flush and irrigation on the reflowering and late ripening of cactus pear *Opuntia ficus-indica* (L.) Mill.

Abstract: The effect of removing the spring flush and three irrigation doses on cactus pear's reflowering and late ripening were studied. Removing the spring flush (scozzolatura practice) and irrigation have a significant effect ($p \leq 0,05$) on the reflowering and late ripening of cactus pear. In not irrigated and not scozzolaturated plants (NINSP), the flowering extended from March 10 to May 25, 2017, and the ripening extended from May 20 to August 15, 2017. Whereas, in irrigated and scozzolaturated plants (ISP) the reflowering extended from June 15 to August 24, 2017, and the ripening extended from July 21 to November 20, 2017. The number of growths was higher in ISP (92-103 per plant) than in NINSP (81 per plant). Fruit yield was higher in NINSP (56.2 t ha^{-1}) than in ISP (26.2-36.5 t ha^{-1}), but fruit mass (123-131 g) and fruit length (7.83-7.92 cm) were higher in ISP than in NINSP (fruit mass: 103 g and fruit length: 7.72 cm). The rate of juice in fruits was also higher in ISP (49-55 %) than in NINSP (43 %), and the content of sugars was higher in NINSP (15.20 °Brix) than in ISP (13.83-14.56 °Brix).

Key words: *Opuntia ficus-indica*; cactus pear, scozzolatura; flowering; ripening; fruit yield, fruit quality

Učinek odstranjevanja spomladanskih cvetnih nastavkov in namakanja na ponovno cvetenje in pozno zorenje plodov opuncije *Opuntia ficus-indica* (L.) Mill.

Izvleček: V raziskavi je bil preučevan učinek odstranjevanja nastavka prvih pomladanskih cvetnih nastavkov in treh namakanj na ponovno in pozno zorenje plodov opuncije. Odstranjevanje nastavka pomladanskih cvetov (postopek «skocolatura» -scozzolatura practice) in namakanja sta imela značilen učinek ($p \leq 0,05$) na ponovno cvetenje in pozno dozorevanje plodov opuncije. Pri nenamakanih in neodstranjenih prvih cvetnih nastavkih (NINSP) je cvetenje potekalo od desetega marca do petindvajsetega maja 2017, zorenje plodov pa od dvajsetega maja do petnajstega avgusta, 2017. Pri namakanih in skocolatiranih rastlinah (ISP) je ponovno cvetenje potekalo od petnajstega junija do štiriindvajsetega avgusta, zorenje plodov pa se je podaljšalo na obdobje od enaindvajsetega julija do dvajsetega novembra, 2017. Število plodov je bilo večje pri ISP rastlinah (92-103 na rastlino) kot pri NINSP rastlinah (81 na rastlino). Pridelek plodov je bil večji pri NINSP (56,2 t ha^{-1}) kot pri ISP rastlinah (26,2-36,5 t ha^{-1}), tudi masa plodov (123-131 g) in dolžina plodov (7,83-7,92 cm) sta bili večji pri pri ISP kot pri NINSP rastlinah (masa plodov 103 g in dolžina plodov 7,72 cm). Delež soka v plodovih je bil pravtako večji pri ISP (49-55 %) kot pri NINSP rastlinah (43 %), a vsebnost sladkorjev je bila večja pri NINSP (15,20 °Brix) kot pri ISP rastlinah (13,83-14,56 °Brix).

Ključne besede: *Opuntia ficus-indica*; plodovi; skocolatura (scozzolatura); cvetenje; zorenje; pridelek plodov; kakovost plodov

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1 INTRODUCTION

In the northern hemisphere, the main flush of flowers of cactus pear is set in spring. But the plant can set another or several flushes of flowers when the climatic conditions are favorable or under advanced management practices like irrigation, fertilization or the removal of the spring flush of flowers and cladodes. The removing of the spring flush is called 'scozzolatura' practice in Italy where it's used to induce a second flush of flowers and cladodes a few weeks later, and a late ripening in September-November (Barbera et al., 1991 and 1992; Barbera & Inglese, 1993; Nerd & Mizrahi, 1994; Mulas, 1997; Anonymus, 2015). The scozzolatura practice was discovered for the first time in Sicily by the beginning of the 19th century. The second flush of flowers depends on the cultivar's aptitude for reflowering, the growing medium's environmental factors, and the time and degree of removing the spring flush (Barbera et al., 1991). Several authors reported that the rate of reflowering is related to the number of removed cladodes, even if their removal is less than that of floral buds (Inglese et al., 1994). The number of floral buds resulting from the scozzolatura practice decreases with increased cladodes left on the plant after this practice (Anonymous, 2015). The full flowering stage (50 % flowers in bloom) may be the favorable period for the scozzolatura practice, leading to the sufficient right of the second flush of flowers and cladodes, and this period could be prolonged till the end flowering (100 % flowers in bloom) (Barbera et al., 1991; Ochoa et al., 2009; Anonymus, 2015). Whereas early removing did not reduce the number of flowers of the second flush, but led to early ripening of the late fruiting (15 to 40 days precocity in comparison with removing applied between the stage of full flowering and end flowering) (Anonymous, 2015). Removing used during the stage of fruit enlargement (after full flowering) negatively affects the number of flowers and the set fruits of the second flush (Barbera et al., 1991; Brutsch & Scott, 1991; Anonymous, 2015; Boujghagh & Bouharroud, 2015). In south Morocco, Boujghagh and Bouharroud (2015 have removed the spring flush during four flowering stages of cactus pear *O. ficus-indica:* (S1) the early stage of flowering (1 % flowers in bloom), (S2) the full flowering stage (50 % flowers in bloom), (S3) the end flowering stage at 50 % fall corollas, and (S4) end flowering stage after 50 % fall corollas. Their results have shown that removing the spring flush of flowers and cladodes in any flowering stage led to a second flush of flowering. Removing applied between S2 and S4 has given a higher rate of reflowering. Other authors (Anonymous, 2015) also reported that removing between the S2 and S4 stages leads to a high number of fruits. Removing the spring flush at S1, S2, S3, and S4 made it possible to delay the reflowering for 25 days with S1, 62 days with S2, 94 days with S3, and 115 days with S4 in comparison to the seasonal flowering of spring. Removing the spring flush at these stages also make it possible to delay the fruit ripening period for 25 days with S1, 43 days with S2, 64 days with S3, and 81 day with S4 compared to the seasonal ripening period (Boujghagh & Bouharroud, 2015). In Argentina, Ochoa et al. (2009) have studied the effects of the scozzolatura practice and irrigation on the reflowering and late fruiting of cactus pear *O. ficus-indica*. Their results have shown that not irrigated plants are flowering before the irrigated plants, and removing the spring flush delays the reflowering for 38 days in not irrigated plants and 85 days in irrigated plants compared to irrigated and not scozzolatured plants.

Fruits from the scozzolatura practice are larger and more delicious than seasonal fruits; they also contain more pulp and fewer seeds (Barbera & Inglese, 1993; Mulas, 1997; Ochoa et al., 2009). Regarding the emission of growths after the scozzolatura, the number of emitted growths is 10 to 40 % less than the spring flush of growths (Inglese, 1995).

The seasonal ripening period of cactus pear in Morocco is in summer between mid-July and mid-August. This seasonal crop exceeds the request of consumers for the fruit, which led to overproduction. The valorization possibilities of this seasonal crop are still limited, and the management practices that can delay the ripening period, mainly removing of the spring flush, prove to be interesting. Even though the scozzolatura practice is known in several countries, the reflowering consequences and the management aspects of the practice are still subject of research studies to be developed. Little information is available on the effect of removing the spring flush and irrigation on the reflowering and late ripening of cactus pear, and on fruit yield and quality (Barbera et al., 1991; Brutsh & Scott, 1991; Ochoa et al., 2009). The goal of this work was to study the effects of the scozzolatura practice and irrigation on the late ripening of cactus pear which is to sell fruits with an interesting price on the local market.

2 MATERIALS AND METHODS

Experiments were carried out in the semi-arid area of Souss Massa in South Morocco, at the experimental station of Hassan II Institute of Agronomy and Veterinary Medicine in Agadir, latitude 30°22' North, longitude 9°39' West and 32 m altitude. Annual rainfall in this area is low (207 mm), the average temperature is for 7 °C in January and 40 °C in August. The soil of the trials site is as follows: 4.3 % coarse sand, 30.1 % fine sand, 26 % coarse silt, 22.8 % fine silt, and 17.6 % clay. The parcel of

trials is equipped with a drip irrigation system and each line of plantation is equipped with a ramp where drippers are spaced 40 cm and their flow rate is 4 liters per hour, and each plant is irrigated with two drippers (flow rate of 8 liters per hour). Trials were carried out on an 18-year-old plantation of cactus pear *O. ficus-indica* 'Aissa'. Plants had an average width of 1.6 m and the average height of 2 m. They were spaced 3 m between lines and 1.5 m between plants (2230 plants ha^{-1}). Irrigation was applied in a single watering and irrigation dose (ID) was determined according to CEMAGREF (1992):

$$ID = f\ x\ (HCC\text{-}HPFP)\ x\ z\ x\ PSH/100$$

ID: Irrigation dose in mm. f: Cultural coefficient (depends on the culture): f = 0.5 for a mean culture with mean rooting. HCC: Humidity at a ground capacity of the field (mm per m depth in soil) (30 %). HPFP: Humidity at permanent withering point (mm per m depth in soil) (15 %). z: The ground depth occupied by most of the roots (60 cm for cactus pear). PSH: Percentage of humidified ground (100 % for full saturation of the ground and 50 % for half saturation)

For full saturation of the ground with water (100 %): *ID = 0.5 x (30 - 15) x 60 x 100/100 = 45 mm*, and for half saturation of the ground (50 %): *ID = 0.5 x (30-15) x 50/100 = 22.5 mm*

Watering duration (wd) is determined as follow:

$$wd = ID/hourly\ rainfall$$

wd: watering duration (in an hour). ID: irrigation dose in one application (in mm). Hourly rainfall (mm/hour) = drippers flow (4 liters per hour) x number of drippers (2) per area really occupied by roots (1 m^2) = 8 mm per hour

For full saturation of the ground with water: wd = 45/8 = 6 hours watering in one application and for half saturation of the ground: wd = 22.5/8 = 3 hours watering in one application

Experimental design was a split-plot with two parameters: (i) irrigation with three treatments: I0 (without irrigation), I1 (irrigation dose of 45 mm in one application for full saturation of the ground), and I2 (irrigation dose of 22.5 mm in one application for half saturation of the ground); (ii) the scozzolatura practice with two treatments: without application of the scozzolatura practice (NS) and with application of the scozzolatura practice (SP). The scozzolatura practice was applied during the full flowering stage (50 % flowers in bloom) on April 27th, 2017. Irrigation treatments were the great plots of parcels and the scozzolatura practice treatments were the small parcels or experimental units with two plants per small parcel.

Statistical analysis of data was carried out with MINITAB software. It focused on the analysis of variance with two parameters, and data analysis was also completed with a comparison of means.

Observations started on February 2017 once a week from the emission of floral buds till the end of the ripening stage of scozzolaturated plants (SP). They focused on the enumeration of flowers and cladodes before and after the scozzolatura practice and irrigation. Observations also were related to the duration of the flowering and ripening stages from the beginning of each stage (5 % flowers in bloom for flowering and 5 % ripened fruits for ripening) till the end of each stage (100 % flowers in bloom for flowering and 100 % ripened fruits for ripening). Fruit yield was determined on two plants per treatment of irrigation or scozzolatura practice and per bloc. Fruit mass and size were determined on a sample of 20 fruits per plant per treatment of irrigation or scozzolatura practice and per bloc; the sample of fruits was randomly harvested on the four orientations of the plants (east, west, north and south). Fruit mass was determined with a balance of 0.01 g of precision and fruit size (length and diameter) and peel thickness were determined with a caliper. The ripening stage is reached when fruit color change from the green to yellowish green, and the percentage of fruits at ripening stage was determined as follow (Oelofse et al., 2006):

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

The organoleptic parameters of the fruit focused on the juice content and sugars (°Brix) in the fruits, the titratable acidity and the pH of the juice. The same sample of fruits used in the determination of fruit mass and size was used for the chemical analysis of the fruits. The number of seeds by fruit was counted. The content of sugars in the fruits was determined with an electronic refractometer HI 96801, and the fruit juice rate was determined by crushing fruits with a mixer and filtering juice in 1 mm sieve to separate seeds from the juice. The percentage of juice in the fruit (J) was determined as follow:

$$\%\ juice\ in\ the\ fruit\ (J) = Juice\ mass/pulp\ mass \times 100$$

The pH of the 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 an

indicator of color change. Titratable acidity (QCA) was determined as follows (IFU, 2017):

$$QAC = 0.64\ x\ V\ \text{NaOH}$$

QAC: Quantity of citric acid (g citric acid per liter of juice). V NaOH: volume NaOH 0.1 N used in the titration.

3 RESULTS AND DISCUSSION

3.1 EFFECTS OF REMOVING THE SPRING FLUSH AND IRRIGATION ON THE REFLOWERING AND LATE RIPENING OF CACTUS PEAR

Removing spring flush had a significant effect ($p \leq 0.05$) on the reflowering and late ripening of cactus pear. In not irrigated plants (NI), the period of flowering of not scozzolaturated plants (NSP) (the spring flush of flowering) extended from March 10th till May 25th 2017, and the period of reflowering of the scozzolaturated plants (SP) (the second flush of flowers) extended from June 10th till July 25th 2017. The average number of flowers per plant was 159 in NSP and 111 in SP. The ratio number of flowers resulting from the scozzolatura practice /number of flowers of the spring flush is 0.69. This is following the results of several authors (Barbera et al., 1991; Anonymus, 2015) who confirmed that the rate of reflowering in cactus pear after the scozzolatura practice is strongly related to the rate of the spring flush. The ratio number of flowers after the scozzolatura practice / number of flowers of the spring flush varies between 0.7 and 1 if the removing of the spring flush is practiced between full flowering and end flowering. Our rate of flowering (0.69) exceeds the rate which is reported by Barbera et al. (1991) (0.50) who indicated that this rate might be sufficient for the second flush of flowers after the scozzolatura practice.

Irrigation had a significant effect ($p \leq 0.05$) on the reflowering of cactus pear. In irrigated and scozzolaturated plants (ISP), the reflowering period extended from June 15 to July 30, 2017 for I2 treatment of irrigation (50 % saturation of the ground) and from June 20 to August 24, 2017 for I1 treatment of irrigation (100 % saturation of the ground). Whereas in not irrigated and scozzolaturated plants (NISP), the reflowering period extended from June 10 to July 25, 2017 (Figure 1). ISP have emitted an average number of 61 flowers per plant for I1 treatment and 85 per plant for I2 treatment. Whereas NISP has emitted an average number of 111 flowers per plant. INSP have emitted an average number of 183 flowers per plant for I1 treatment and 179 per plant for I2

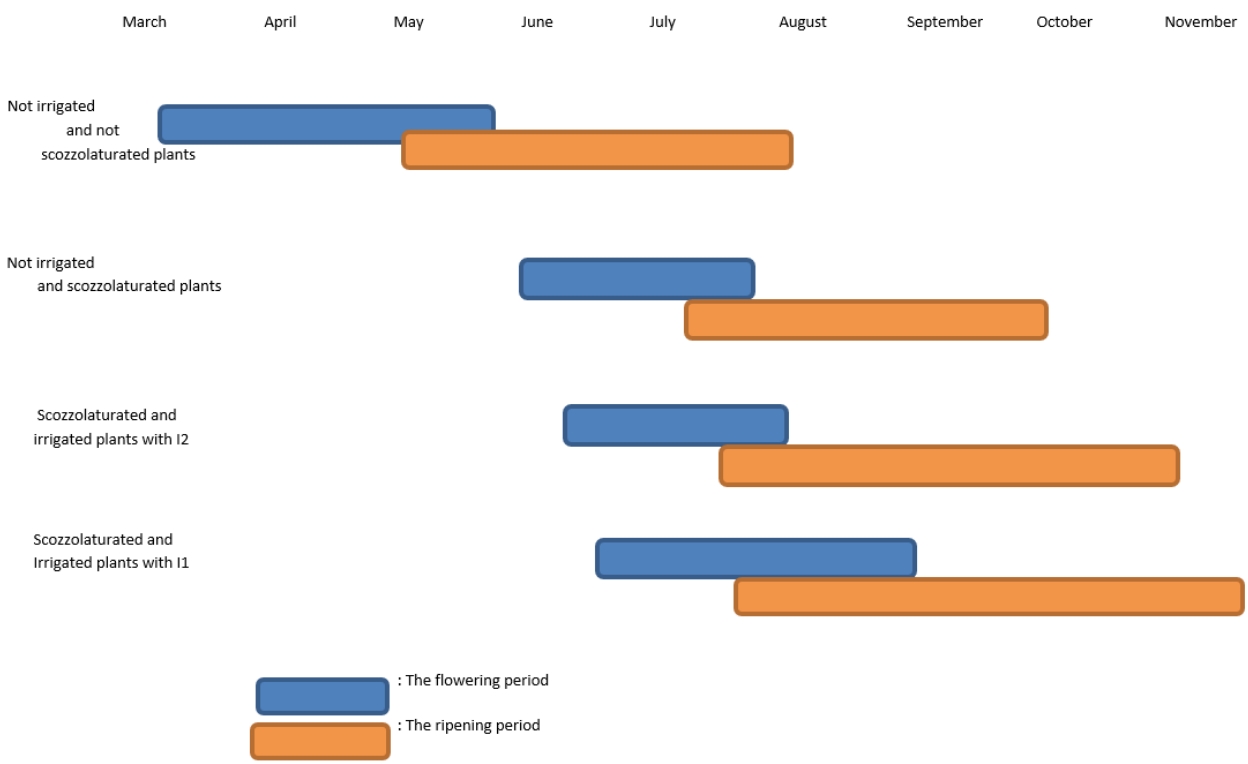

Figure 1: Effect of the scozzolatura practice and irrigation on the reflowering and late ripening periods of cactus pear (*Opuntia ficus-indica* (L.) Mill.) in Souss-Massa area

treatment (Table 1). The rate of reflowering in ISP is for 69 % for I0. 33 % for I1 and 47 % for I2. According to Barbera et al. (1992) and Anonymous (2015), this rate of reflowering may be sufficient for I0 (69 %) and I2 (47 %) and insufficient for I1 (33 %). In comparison with not irrigated plants, irrigation of cactus pear after the scozzolatura practice disadvantages the initiation of flowers. Interaction of the two factors irrigation and scozzolatura practice had significant effect ($p \leq 0{,}001$) on the reflowering of cactus pear. In NINSP, the average number of flowers was 159 per plant, whereas in ISP the average number was 61 to 85 per plant (Table 1). Our results on IP with I2 (which is a moderate amount of irrigation in comparison with I1), and NSP, are similar to those of Arba et al. (2018) who reported that irrigation of not scozzolaturated plants with a moderate amount of water in spring (30 mm) had increased the emission of floral buds.

The scozzolatura practice significantly affected the late ripening of cactus pear. The ripening period of NINSP extended from May 20th to August 15th 2017, and the ripening period of NISP extended from June 15th to October 10th 2017. Whereas the ripening period of ISP extended from July 28th to November 20th 2017 for I1 and from July 20st to November 12th 2017 for I2 (Figure 1). Our results are similar to those of Ochoa et al. (2009) who reported that in SP the reflowering and fruiting periods are more lately in irrigated plants than in not irrigated ones. According to several authors (Barbera et al., 1991; Brutsch & Scott, 1991), the period when the scozzolatura practice is applied also affect the ripening period. Boujghagh & Bouharroud (2015) indicated that removing the spring flush before flowering led to early ripening for 15 to 20 days compared to removing applied in full flowering, and for 30 to 40 days in comparison to removing applied in end flowering.

3.2 EFFECT OF REMOVING THE SPRING FLUSH AND IRRIGATION ON THE INITIATION OF GROWTHS

The scozzolatura practice had significant effect on the initiation of growths. In not irrigated plants, the number of growths was higher in NSP (81 per plant) than in SP (21 per plant). Whereas in irrigated plants, the initiation of growths was higher in SP (103 per plant for I1 and 92 for I2) than in NSP (72 per plant for I1 and 80 for I2) (Table 1). Interaction of the two factors had a very significant effect ($p \leq 0.01$) on the initiation of growths. Our results are similar to those of Inglese (1995) who reported that in NIP, the number of growths was lower in SP (10 to 40 %) than in NSP (more than 50 %), but in IP the number of growths was higher in SP than in NSP. Arba (2017) and Arba et al. (2018) also reported that irrigation increased the initiation of growths in cactus pear.

3.3 EFFECT OF REMOVING THE SPRING FLUSH AND IRRIGATION ON FRUIT YIELD AND QUALITY

3.3.1 Effect on fruit yield and fruit size

The scozzolatura practice had no significant effect ($p \geq 0.05$) on the peel mass and skin thickness. SP and NSP have a similar peel mass of 52 g and a similar skin thickness of 4.5 mm. Therefore, irrigation had a significant effect ($p \leq 0{,}001$) on the peel mass and skin thickness. The fruits of IP, scozzolaturated or not, have higher skin mass (53 to 57 g) and skin thickness (4.52 to 4.92 mm) than the fruits of NIP, scozzolaturated or not (skin mass of 47 g and skin thickness of 4.12 mm). Interaction of the two factors had significant effect ($p \leq 0{,}001$) on the

Table 1 : Effect of the scozzolatura practice and irrigation on the initiation of flowers and growths in cactus pear *Opuntia ficus-indica* (L.) Mill. in Souss-Massa area

	Not scozzolaturated plants (NSP)	Scozzolaturated plants (SP)
Traitments of irrigation	Number of emitted flowers per plant	
I0	159 ± 3 a	111 ± 2,5 b
I1	183 ± 4 ab	61 ± 1,5 d
I2	179 ± 4 a	85 ± 1,5 c
	Number of emitted growths per plant	
I0	81 ± 3,5 ab	21 ± 1,3 c
I1	72 ± 3 b	103 ± 4 d
I2	80 ± 3,5 b	92 ± 4 ad

I0: Without irrigation; I1: Saturation of the ground with water; I2: Half saturation of the ground with water
a, b, c and d: Comparison groups according to Tukey test with a confiance level of 95 %

Table 2 : Effect of the scozzolatura practice and irrigation on fruit yield and fruit size of cactus pear *Opuntia ficus-indica* (L.) Mill. in Souss Massa area.

	Not scozzolaturated plants			Scozzolaturated plants		
	Treatments of irrigation					
	I0	I1	I2	I0	I1	I2
Fruit yield (t ha^{-1})	56,2 ± 2,5	62,5 ± 3	71,5 ± 3,5	44,1± 1,5	26,2 ± 1	36,5 ± 1,5
Fruit lenght (cm)	7,46	7,52	7,57	7,72	7,83	7,92
Fruit diameter (cm)	5,23	5,41	5,56	5,17	5,46	5,83
Fruit mass (g)	103,4 ± 3 a	120,9 ± 3,5 bc	119,3 ± 3,5 c	106,9 ± 3 d	130,9 ± 4 a	122,9 ± 3,5 b
Pulp mass (g)	55,99 ± 3 e	68,59 ± 3,5 b	62,39 ± 3 c	59,67 ± 3 d	75,10 ± 4 a	69,74 ± 3,5 b
Peel mass (Effect of removing the spring flush and irrigation on the reflowering and late ripening of cactus pear *Opuntia ficus-indica* (L.) Mill.)	47,38 ± 2,5 c	52,33 ± 3 b	56,96 ± 3 a	47,21 ± 2,5 c	55,76 ± 3 ab	53,15 ± 3 b
Peel thikness (mm)	4,10 d	4,86 b	4,87 bcd	4,13 cd	5,10 a	4,56 bc
Number of seeds / 10 g pulp	47,41 ± 2,5 a	45,79 ±2 ab	46,37 ±2,5 a	45,96 ±2,5 a	41,93 ± 2 c	44,10 ± 2 b

I0: Without irrigation; I1: Saturation of the ground with water ; I2: Half saturation of the ground with water
a, b, c and d: Comparison groups according to Tukey test with a confiance level of 95 %

skin mass, skin thickness, and on the number of seeds per fruit. Average number of seeds per fruit was lower in SP (44 per 10 g pulp) than in NSP (47 per 10 g pulp) and average number of seeds per fruit in IP, scozzolaturated or not, was lower (42 to 46 per 10 g pulp) than that of NIP, scozzolaturated or not (46 to 48 seeds per 10 g pulp). Barbera & Inglese (1993) and Mulas (1997) also have reported that the fruits of SP contain fewer seeds than those of NSP.

3.3.2 Effect on the organoleptic parameters of the fruits

The scozzolatura practice and irrigation, and the interaction of the 2 factors have a significant effect ($p \leq$ 0,001) on the content of juice in the fruits. The rate of juice in the fruits of ISP was higher (49 to 55 %) than that of NINSP (43 %) (Table 3).

The scozzolatura practice and irrigation also have a significant effect ($p \leq 0{,}001$) on the content of sugars in the fruits. The rate of sugars was higher (15.20 °Brix) in the fruits of NISP than in those of NINSP (14.13 °Brix), the fruits of ISP (13.83 to14.56 °Brix) and those of INSP (12.91 to 13.11 °Brix) (Table 3). Interaction of the two factors had no significant effect ($p \geq 0.05$) on the content of sugars in the fruits. Several authors also reported that the fruits of SP are tastier and sweeter than the fruits of NSP (Barbera & Inglese, 1993; Mulas, 1997; Ochoa et al., 2009; Anonymous, 2015), and other authors indicated that irrigation decreases the rate of sugars in the juice due to dilution and increases the content of juice in the fruits (Felker et al., 2002; Barbara, 2007; Arba, 2017; Arba et al., 2021). The scozzolatura practice and rrigation also have significant effect ($p \leq 0{,}001$) on the content of citric acid in the fruits and on the pH of juice. The rate of citric acid in the fruits (15.20 g l^{-1} of juice) and the pH of juice (6.28) were higher in NISP than in NINSP (14.13 g/l for the citric acid and 5.98 for the pH), and the content of acidity and the pH of juice (13.83 to 14.56 g l^{-1} for the citric acid and 6.37 to 6.49 for the pH) were also higher in ISP than in INSP (12.91 to13.11 g l^{-1} for the citric acid and 6.23 to 6.35 for the pH) (Table 3). Interaction of the two factors also had significant effect ($p \leq 0{,}001$) on the rate of acidity and the pH of juice. Our results are similar to those of several authors (Barbera & Inglese, 1993; Mulas, 1997; Anonymous 2015) who reported that the fruits of SP are tastier than those of NSP since the acidity rate in the fruits is an essential criterion in the fruit flavour.

4 CONCLUSIONS

The scozzolatura practice leads to the emission of the second flush of flowers and the rate of reflowering may be sufficient since it exceeded 50 % of the spring flush. In SP, irrigation favored the emission of growths than flowering. The scozzolatura practice and irrigation significantly affect the late ripening of cactus pear in Souss-Massa area. The late ripening was at least one

Table 3: Effect of the scozzolatura practice and irrigation on the content of juice and sugars in the fruits, and on the titratable acidity and the pH of juice of *O. ficus-indica* (L.) Mill. in Souss-Massa area

	Not scozzolaturated plants			Scozzolaturated plants		
	Traitments of irrigation					
	I0	I1	I2	I0	I1	I2
The content of juice n the fruits (%)	43,20 ± 2 f	51,33 ± 4 b	46,46 ± 3 d	44,96 ± 4 e	55,41 ± 3 a	49,09 ± 3 c
The content of sugars in the fruits (°Brix)	14,13 ± 0,4 b	12,91 ± 0,3 d	13,11 ± 0,5 cd	15,20 ± 0,3 a	13,83 ± 0,5 bc	14,56 ± 0,4 ab
The content of citric acide in the fruits (g l^{-1} juice)	1,337 a	1,100 cd	1,217 b	1,289 a	1,071 d	1,141 c
pH of the juice	5,98 d	6,35 b	6,23 c	6,28 ab	6,49 a	6,37 b

I0: Without irrigation; I1: Saturation of the ground in water ; I2: Half saturation of the ground in water
a, b, c, d, e and f: Comparison groups according to Tukey test with a confiance level of 95 %

month later in ISP than in NISP and NINSP, and the ripening of NISP was two months later than that of NINSP. Fruit yield was lower in ISP than in NISP and NINSP. Therefore, fruit size was larger in ISP than in NISP and NINSP. Irrigation increased the skin mass and thickness in the fruits of SP and NSP, but the scozzolatura practice did not affect these parameters. Irrigation and the scozzolatura practice improved the juice rate in the fruits, but they decreased the rate of sugars, the acidity and the pH of juice, and the number of seeds in the fruits.

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