



## Pomological evaluation of four mains introduced almond cultivars in North Eastern region of Morocco

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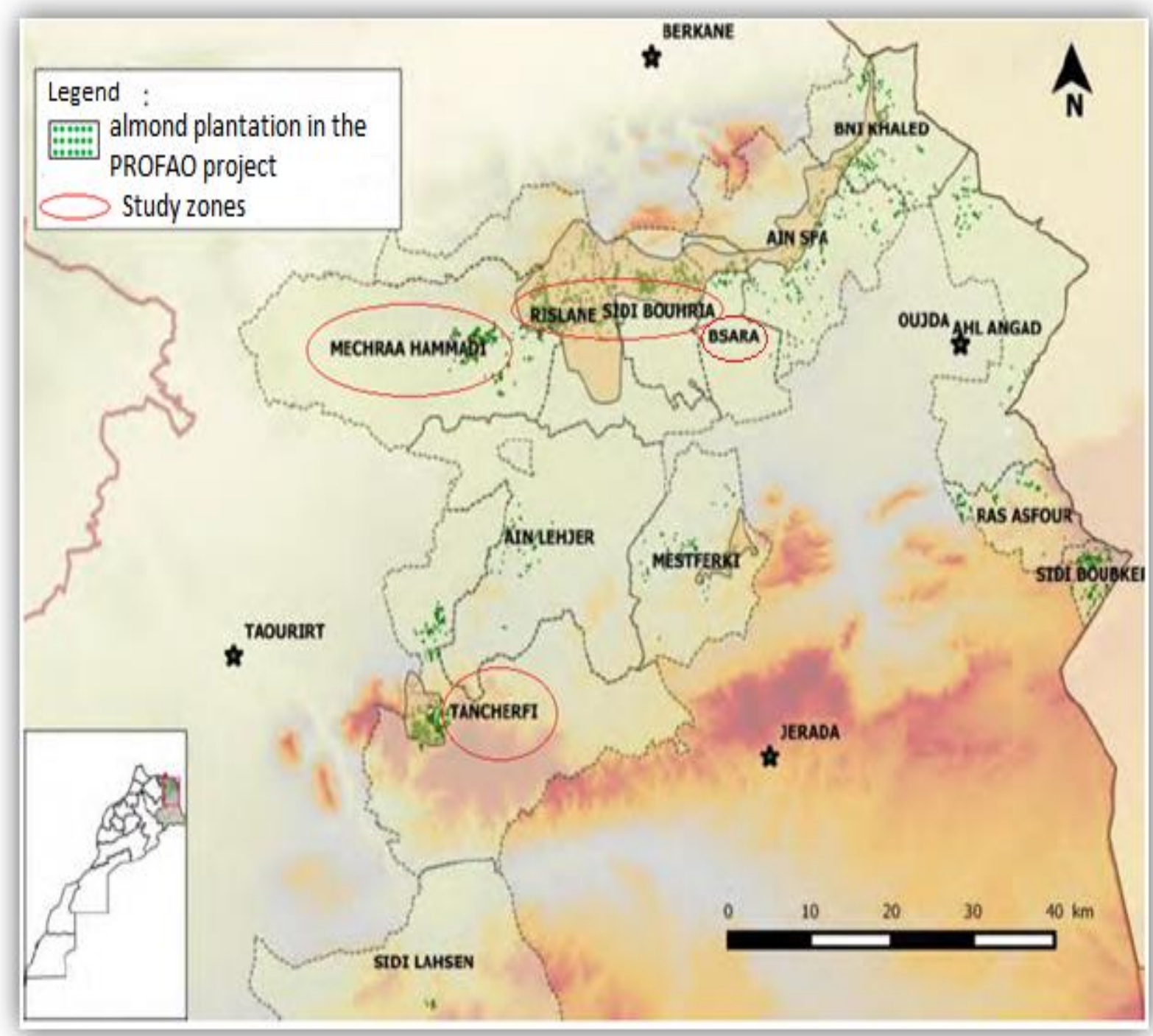
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**Introduction:** Almond (*Prunus dulcis* L.) is one of the most important cultivated fruit trees in north eastern region of Morocco. Recently, as part of the Green Morocco program, North Eastern region of Morocco was supported by the Belgian development agency through the "PROFAO\*" project for planting 6000 ha of almond trees. Ferragnes and Ferraduel, two French cultivars known for their late flowering in March to escape the late frosts of spring, were chosen for the planting of these new almond orchards, instead of "Marcona" and "Fournat" which also have been previously introduced in this region, but appears to be sensitive to spring frost due to their flowering in February.

This work focuses on the pomological characterization of these four almond cultivars (Ferragnes, Ferraduel, Marcona and Fournat) in five studied areas in North Eastern region of Morocco. For each almond cultivar, recorded pomological measurements for the fruit and kernel are: weight, width, length, thickness, volume and percentage of the double kernels

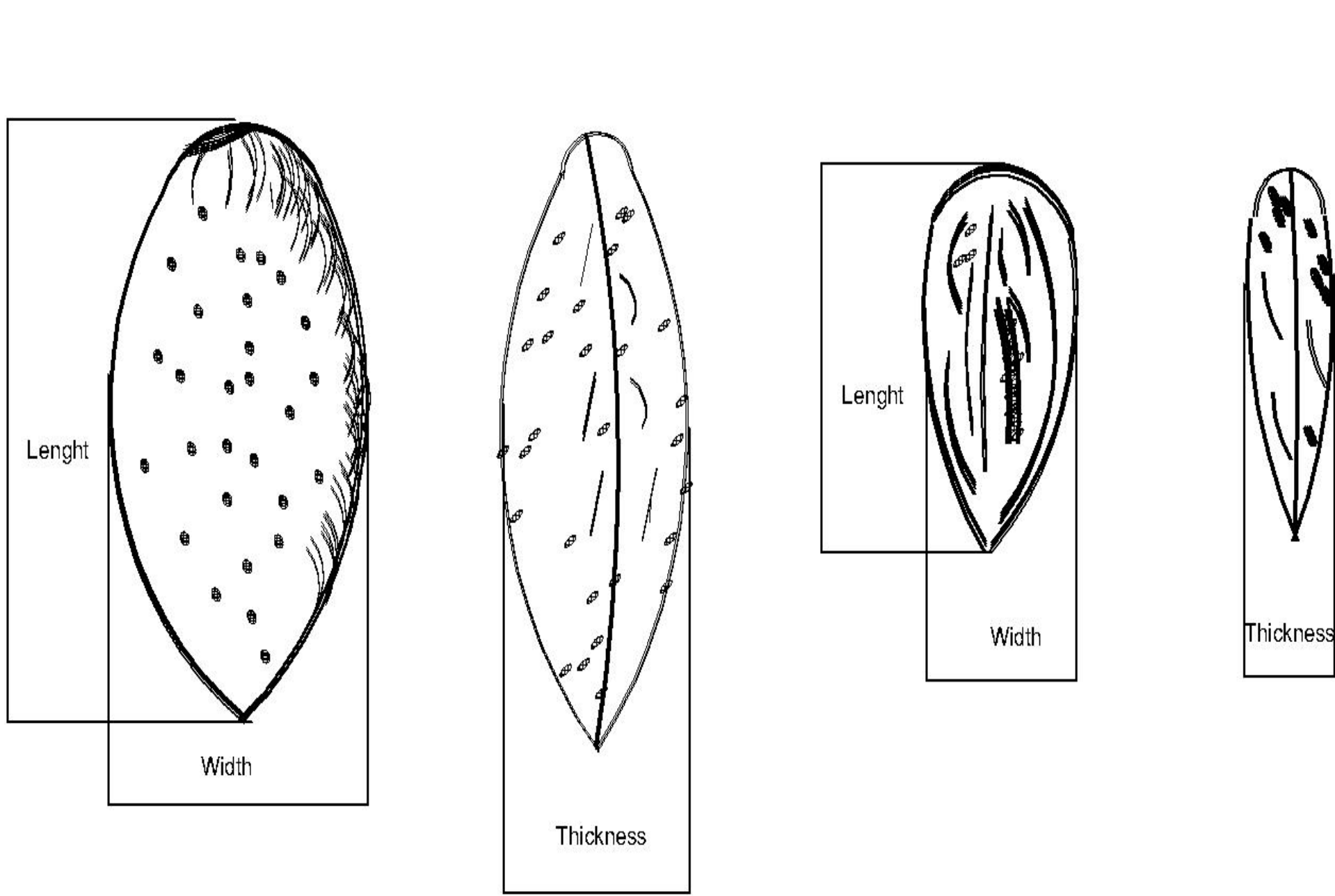
\*PROFAO: Projet Filière Amandier dans l’Oriental (2011-2017): “The almond value chain in eastern Morocco

**Methodology :** Measured and calculated parameters for almond nut and kernel were carried out during the harvest period in summer 2017. in five studied areas in North Eastern region of Morocco (Figure 1)

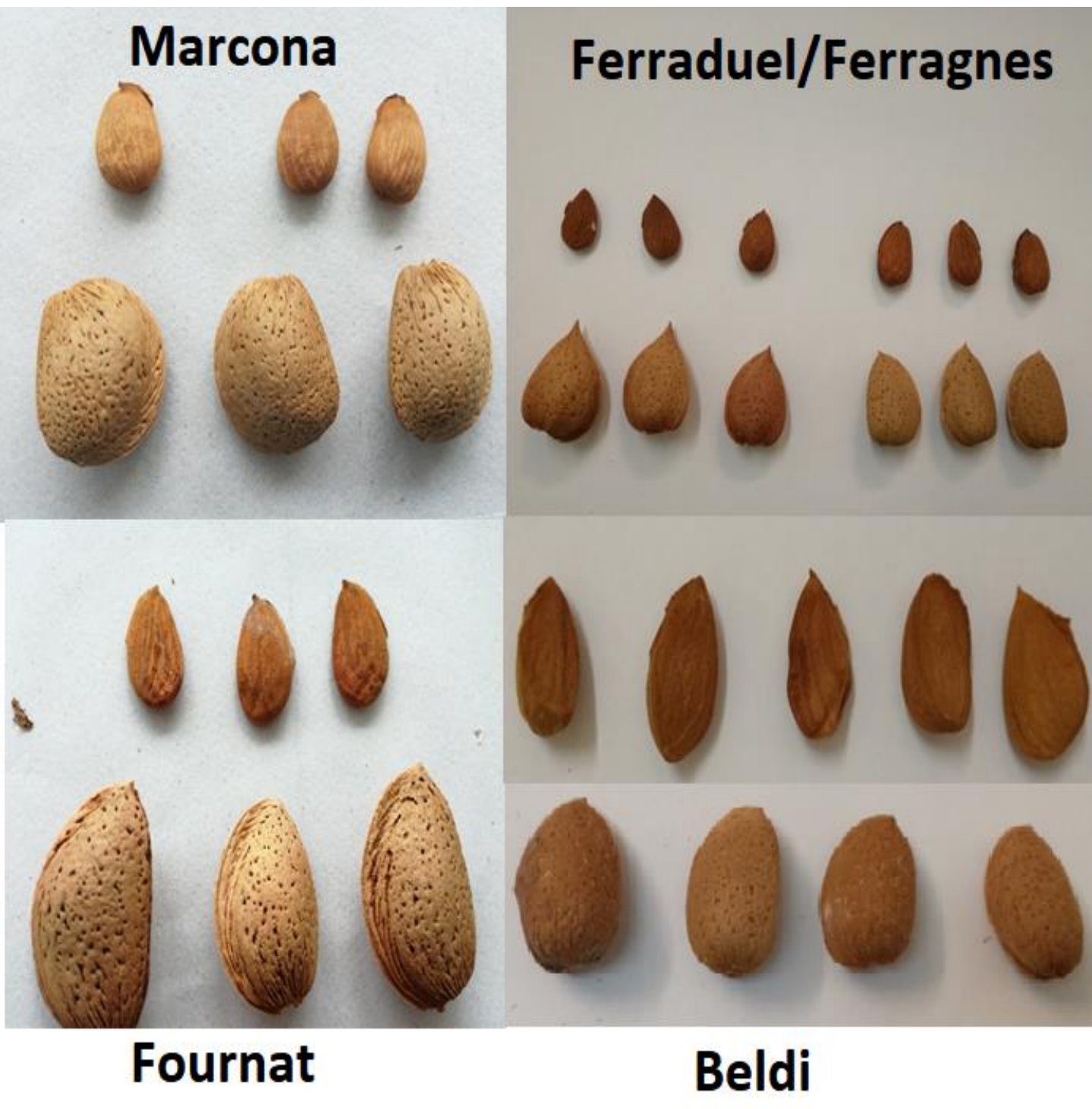


**Figure 1:** Geographic localization of almond plantation and the encircled studies sites.

Area 1: TANCHERFI, Area 2:MECHRAA HAMMADI, Area 3: SIDI BOUHRIA, Area 4:RISLANE, area 5:BSARA



**Figure 2:** The Measurement of fruit and kernel dimensions



**Figure 3:** mains introduced almond cultivars and ecotype varieties in North Eastern region of Morocco

**Results :** The calculated parameters are: Weight, length, thickness, diameter (Dg), sphericity, volume, shelling, kernel shape double percentage, the results of pomological parameters are presented in (Table 1 and 2)

**Table 1 :** Nuts characteristics of Ferragnes, Ferraduel, Marcona and Fournat varieties in 5 different areas in North Eastern region of Morocco

parameters	Area	Marcona	Fournat	Ferragnes	Ferraduel
Weight (g)	1	4.26 <sup>a</sup> b	4.41 <sup>a</sup> b	3.51 <sup>ab</sup> a	4.22 <sup>a</sup> b
	2	3.14 <sup>b</sup> c	3.55 <sup>ab</sup> c	3.68 <sup>a</sup> a	2.69 <sup>b</sup> b
	3	3.18 <sup>b</sup> c	3.62 <sup>a</sup> a	3.47 <sup>b</sup> a	3.88 <sup>c</sup> b
	4	3.88 <sup>c</sup> c	3.34 <sup>b</sup> d	2.65 <sup>c</sup> a	3.11 <sup>d</sup> b
	5	3.46 <sup>d</sup> a	3.30 <sup>b</sup> a	3.33 <sup>b</sup> a	3.33 <sup>d</sup> b
Width (mm)	1	25.07 <sup>a</sup> c	27.65 <sup>d</sup> d	21.84 <sup>a</sup> a	24.39 <sup>a</sup> b
	2	22.58 <sup>b</sup> a	24.25 <sup>b</sup> b	22.00 <sup>a</sup> a	22.40 <sup>b</sup> a
	3	22.73 <sup>b</sup> a	25.42 <sup>c</sup> b	22.68 <sup>b</sup> a	25.17 <sup>c</sup> b
	4	24.86 <sup>a</sup> c	24.33 <sup>b</sup> d	19.63 <sup>c</sup> a	20.84 <sup>d</sup> b
	5	23.50 <sup>c</sup> b	24.86 <sup>cb</sup> c	21.74 <sup>a</sup> a	23.06 <sup>b</sup> a
Lenght (mm)	1	28.88 <sup>a</sup> c	41.15 <sup>d</sup> d	33.74 <sup>a</sup> a	35.04 <sup>a</sup> b
	2	26.48 <sup>b</sup> c	34.57 <sup>b</sup> d	33.36 <sup>a</sup> a	31.41 <sup>b</sup> b
	3	26.55 <sup>b</sup> c	36.54 <sup>b</sup> b	32.74 <sup>a</sup> a	35.47 <sup>a</sup> b
	4	27.94 <sup>c</sup> a	34.85 <sup>b</sup> b	28.02 <sup>b</sup> a	27.61 <sup>c</sup> a
	5	26.15 <sup>b</sup> c	35.23 <sup>b</sup> d	32.67 <sup>a</sup> a	32.12 <sup>b</sup> b
Thickness (mm)	1	16.07 <sup>a</sup> b	16.16 <sup>a</sup> b	14.19 <sup>ab</sup> a	14.26 <sup>ab</sup> a
	2	14.47 <sup>b</sup> c	14.07 <sup>b</sup> d	15.04 <sup>c</sup> a	13.65 <sup>a</sup> b
	3	14.54 <sup>b</sup> a	15.37 <sup>a</sup> a	15.41 <sup>c</sup> a	15.53 <sup>c</sup> a
	4	16.86 <sup>c</sup> c	14.96 <sup>d</sup> b	13.83 <sup>a</sup> a	14.98 <sup>bc</sup> b
	5	15.57 <sup>d</sup> c	14.93 <sup>d</sup> a	14.94 <sup>bc</sup> a	14.19 <sup>ab</sup> b
Dg (mm)	1	22.66 <sup>a</sup> b	26.38 <sup>c</sup> c	21.86 <sup>a</sup> a	23.00 <sup>a</sup> b
	2	20.52 <sup>b</sup> c	22.74 <sup>b</sup> a	22.26 <sup>ab</sup> a	21.25 <sup>b</sup> b
	3	20.62 <sup>b</sup> c	24.25 <sup>c</sup> b	22.39 <sup>b</sup> a	24.00 <sup>c</sup> b
	4	22.70 <sup>a</sup> c	23.31 <sup>d</sup> d	19.66 <sup>a</sup> a	20.44 <sup>d</sup> b
	5	21.22 <sup>c</sup> b	23.55 <sup>d</sup> c	21.97 <sup>ab</sup> a	21.88 <sup>b</sup> b
Sphericity %	1	78.48 <sup>a</sup> b	64.15 <sup>a</sup> a	64.85 <sup>a</sup> a	65.72 <sup>a</sup> b
	2	77.53 <sup>a</sup> c	65.91 <sup>b</sup> a	66.74 <sup>ab</sup> ab	67.74 <sup>ac</sup> b
	3	77.71 <sup>a</sup> b	66.38 <sup>b</sup> a	69.49 <sup>bc</sup> a	67.69 <sup>ac</sup> a
	4	81.30 <sup>b</sup> c	66.94 <sup>b</sup> d	70.24 <sup>c</sup> a	74.43 <sup>bb</sup> b
	5	81.21 <sup>b</sup> c	66.88 <sup>bb</sup> b	67.29 <sup>abc</sup> ab	68.28 <sup>c</sup> a
Volume (mm³)	1	6110.91 <sup>a</sup> b	9667.20 <sup>c</sup> c	5489.13 <sup>a</sup> a	6399.57 <sup>b</sup> b
	2	4552.59 <sup>b</sup> c	6202.62 <sup>b</sup> d	5795.85 <sup>ab</sup> a	5050.75 <sup>d</sup> b
	3	4613.82 <sup>b</sup> c	7489.45 <sup>c</sup> b	5920.93 <sup>b</sup> a	7326.99 <sup>b</sup> b
	4	6143.98 <sup>a</sup> c	6673.16 <sup>d</sup> d	4000.98 <sup>a</sup> a	4519.05 <sup>c</sup> b
	5	5034.34 <sup>c</sup> c	6864.32 <sup>d</sup> b	5583.01 <sup>a</sup> a	5584.35 <sup>d</sup> b

Significant differences in the same row are shown by different letters (a-d) (p<0.05).  
exponential letters: Significant differences intra-variatal. letter in the same line: Significant differences inter-variatal

**Table 2:** Kernels characteristics of Ferragnes, Ferraduel, Marcona and Fournat varieties in 5 different areas in North Eastern region of Morocco

parameters	Area	Marcona	Fournat	Ferragnes	Ferraduel
Weight (g)	1	0.86 <sup>c</sup> c	1.38 <sup>d</sup> d	1.05 <sup>ab</sup> a	0.95 <sup>ab</sup> b
	2	0.73 <sup>b</sup> c	1.01 <sup>d</sup> D	1.19 <sup>a</sup> a	0.83 <sup>b</sup> b
	3	0.74 <sup>b</sup> c	1.16 <sup>d</sup> d	1.02 <sup>a</sup> a	0.94 <sup>ab</sup> b
	4	0.90 <sup>ab</sup> b	1.06 <sup>b</sup> c	0.88 <sup>d</sup> ab	0.82 <sup>b</sup> a
	5	0.76 <sup>b</sup> b	1.02 <sup>a</sup> a	1.09 <sup>b</sup> a	0.85 <sup>b</sup> b
Width (mm)	1	14.81 <sup>ab</sup> b	16.06 <sup>c</sup> c	13.63 <sup>a</sup> a	14.83 <sup>b</sup> b
	2	13.20 <sup>b</sup> b	14.66 <sup>b</sup> c	13.82 <sup>ab</sup> a	13.48 <sup>ab</sup> ab
	3	13.38 <sup>b</sup> c	15.33 <sup>c</sup> b	14.42 <sup>b</sup> a	14.57 <sup>a</sup> ab
	4	14.78 <sup>ab</sup> b	14.84 <sup>bb</sup> b	12.39 <sup>a</sup> a	12.41 <sup>c</sup> a
	5	13.25 <sup>b</sup> b	14.60 <sup>b</sup> c	13.82 <sup>ab</sup> a	13.52 <sup>ab</sup> ab
Lenght (mm)	1	19.37 <sup>c</sup> c	28.80 <sup>d</sup> d	25.12 <sup>a</sup> a	24.21 <sup>b</sup> b
	2	17.92 <sup>b</sup> c	25.71 <sup>bcd</sup> d	25.06 <sup>a</sup> a	22.01 <sup>b</sup> b
	3	18.43 <sup>b</sup> b	26.22 <sup>b</sup> c	23.55 <sup>a</sup> a	23.33 <sup>a</sup> a
	4	19.00 <sup>ab</sup> b	25.29 <sup>c</sup> c	21.36 <sup>a</sup> a	21.12 <sup>a</sup> a
	5	17.79 <sup>b</sup> c	25.64 <sup>bcd</sup> d	24.20 <sup>a</sup> a	21.58 <sup>b</sup> B
Thickness (mm)	1	6.94 <sup>c</sup> c	6.35 <sup>b</sup> b	7.19 <sup>a</sup> a	6.56 <sup>ac</sup> b
	2	6.79 <sup>a</sup> c	6.1b <sup>d</sup> d	8.17 <sup>b</sup> a	6.51 <sup>ac</sup> b
	3	7.23 <sup>b</sup> c	6.53 <sup>ab</sup> b	7.60 <sup>a</sup> a	6.65 <sup>ab</sup> b
	4	7.29 <sup>bb</sup> b	6.23 <sup>bc</sup> c	7.83 <sup>a</sup> a	7.01 <sup>bb</sup> b
	5	7.30 <sup>ba</sup> a	6.06 <sup>b</sup> b	7.56 <sup>a</sup> a	6.33 <sup>cb</sup> b
Dg (mm)	1	12.57 <sup>b</sup> b	14.31 <sup>c</sup> c	13.5 <sup>a</sup> a	13.29 <sup>a</sup> a
	2	11.71 <sup>b</sup> c	13.19 <sup>b</sup> d	14.13 <sup>b</sup> a	12.44 <sup>b</sup> b
	3	12.11 <sup>c</sup> c	13.79 <sup>c</sup> c	13.67 <sup>a</sup> a	13.11 <sup>b</sup> b
	4	12.68 <sup>a</sup> a	13.26 <sup>c</sup> c	12.7 <sup>a</sup> a	12.23 <sup>b</sup> b
	5	11.97 <sup>b</sup> b	13.13 <sup>c</sup> c	13.61 <sup>a</sup> a	12.48 <sup>b</sup> b
Sphericity %	1	64.95 <sup>c</sup> c	49.72 <sup>d</sup> d	53.77 <sup>a</sup> a	54.96 <sup>b</sup> b
	2	65.35 <sup>b</sup> b	51.34 <sup>b</sup> c	56.42 <sup>b</sup> a	56.62 <sup>a</sup> a
	3	65.79 <sup>ab</sup> c	52.61 <sup>d</sup> d	58.1 <sup>a</sup> a	56.25 <sup>b</sup> b
	4	66.81 <sup>bc</sup> c	52.45 <sup>d</sup> d	59.53 <sup>d</sup> a	57.97 <sup>b</sup> b
	5	67.35 <sup>b</sup> b	51.26 <sup>b</sup> c	56.27 <sup>a</sup> a	56.78 <sup>a</sup> a
Volume (mm³)	1	1044.45 <sup>ab</sup> b	1553.01 <sup>c</sup> c	1293.03 <sup>a</sup> a	1237.74 <sup>a</sup> a
	2	0846.09 <sup>b</sup> c	1209.82 <sup>d</sup> d	1484.64 <sup>b</sup> a	1014.30 <sup>b</sup> b
	3	0935.16 <sup>c</sup> c	1378.01 <sup>c</sup> a	1354.51 <sup>a</sup> a	1185.18 <sup>ab</sup> b
	4	1071.46 <sup>a</sup> a	1234.25 <sup>b</sup> c	1084.97 <sup>a</sup> a	0962.35 <sup>bb</sup> b
	5	0904.96 <sup>bc</sup> b	1191.10 <sup>b</sup> c	1329.27 <sup>a</sup> a	0963.78 <sup>bb</sup> b
Sheling %	1	20.27 <sup>c</sup> c	30.64 <sup>a</sup> a	29.8 <sup>a</sup> a	22.52 <sup>b</sup> b
	2	23.58 <sup>b</sup> c	33.19 <sup>c</sup> b	32.34 <sup>ab</sup> ab	30.83 <sup>a</sup> a
	3	23.54 <sup>b</sup> c	32.88 <sup>bc</sup> d	30.21 <sup>a</sup> a	25.62 <sup>b</sup> b
	4	23.42 <sup>b</sup> c	32.35 <sup>ab</sup> a	33.54 <sup>a</sup> a	25.45 <sup>bb</sup> b
	5	22.03 <sup>a</sup> a	30.97 <sup>ab</sup> b	32.75 <sup>bc</sup> a	30.04 <sup>b</sup> b
Double %	1	0	0	0	0
	2	0	0	0	0
	3	0	7	12	15
	4	0	0	0	15
	5	0	0	0	0

**Conclusion:** Nuts weight ranges between a minimum value of 2.65g for *Ferragnes* and a maximum value of 4.41g for *Fournat*, while the kernels’ weight ranges between 0.73g for *Marcona* and 1.38g for *Fournat*. Calculated mean values of nuts and kernels volumes are respectively 4000.98mm3 and 846.09mm3 for Marcona, considered as small fruits, and 9667.20mm3, 1553.01mm3 for Fournat considered as big fruits in this study, however intermediate values have been recorded for nuts and kernels of Ferragne and Ferraduel. Finally, yield after shelling and the percentage of doubles kernels have been determined, they range from 20.27% to 33.54% and from 0% to 15% respectively

This work gives the possibility of determine each variety, and show the effect of geographical localization of five zones and determine the most profitable areas. Moreover, this result be used for pushing studies on almond cultivation in this region to improve the quality of almond fruits in this areas