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## ANATOMICAL STUDY OF MORINGA LEAF (*MORINGA OLEIFERA* LAM.) UNDER IRON FERTILIZATION

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### ABSTRACT

The effect of different levels of nano- and mineral-Iron and their method of application on anatomical properties of the upper and lower epidermis of Moringa (*Moringa oleifera* Lam.) leaves was studied. Seeds of Moringa were sown in 15 kgs soil capacity pots during the growing season of 2018/2019 arranged as a factorial experiment within Completely Randomized Design, with three replicates. The factors were a method of fertilization (soil or foliar application), three levels i.e. 0, 180 and 360 mg.l<sup>-1</sup> of each of mineral and nano-Iron. The total number of experimental units was 2×3×3×3 for method, nano-Iron, mineral-Iron, and replicates respectively. The application method caused an increase in the mean dimensions of normal epidermis cells, stomatoes, and hairs. These traits were increased as Iron levels increased. Where 360 mg.l<sup>-1</sup> of both types of Iron gave the highest dimensions. Soil application gave higher values of epidermis dimensions than that obtained from the foliar application. The number of stomatoes increased with increasing the level of Iron. The number of normal epidermis cells was conversely proportioned with their volume.

**Keywords:** Moringa, Leaves, Iron, Fertilization

### Introduction

Moringa (*Moringa oleifera* Lam.) is one of Moringaceae family grown mainly in arid and semi-arid areas. It grows better in dry sandy soils, tolerates the poor soils. The main origin area of Moringa is the southern Himalayan mountains in Northern West of India (Radovich, 2010). It has got high value as medicinal and nutritional usages. It is considered a good source for proteins, vitamins, B-carotene, amino acids, and different phenols. Moringa plant is rich in Zeatin, Quercetin, and Sitosterol.

Micronutrients play a good role in increasing productivity of plants, among these nutrients is the Iron (Fe) which is considered as a co-factor for about 140 enzymes that important in biochemical reactions (Brittenham, 1994). Iron is an essential nutrient for all plants. Iron deficiency causes a reduction in the activity of photosynthesis leading to a reduction in the plant biomass (Briat *et al.*, 2007). It participates in photosynthesis, thylakoids synthesis, plastids formation and RNA synthesis (Sheykhbaglou *et al.*, 2010).

Nanotechnology is one of the modern technologies that recently introduced to Iraq which enters in most of our life activities. One of these activities is the fertilization and nutrients application in high efficiency. (Quresh *et al.*, 2018) concluded that nano-fertilization leads to high efficiency in fertilizer application, decreasing the toxicity in soil that results from excess dosage of fertilization or from repeating of fertilization. Plants possess a certain strategy or mechanism to take up Iron. Apart from Poaceae family all dicotyledons and monocotyledon, plants have efficient methods to absorb Iron (Bienfait, 1988; Brown & Jolley, 1988;

Marschner *et al.*, 1986; Romheld & Marschner, 1986). These strategies lead to changes in physiology, morphology and anatomy of plants. Many anatomical studies of stem and leaves tissues of different plant species were carried out in order to assess the effect of different nutrients addition especially Fe on the plant tissues (Agamy, 2004) on sweet potato and studies of (Ahmad Nazarudin *et al.*, 2007; Xu *et al.*, 2008). They found an increase in the thickness of epidermis, cortex and number and dimensions of vascular bundles of stems. (Mohammed, 2005) studied nutrients including Fe effect on the stems tissue of Dill plant. (Youssef and Abd El-Aal, 2013) also found an effect of Iron on the thickness of leaves and stem tissues of Moringa plants. Iron application also affected the leaves and stem tissues of *X. chrysanthus*. (Salama and Yousef, 2015) also found the same effect on *Ocimum sanctum*. It is worth mentioning that most previous studies dealt with tissues of stem and leaves transects, but there is no study carried out on the effect of Fe on the epidermis of leaves except that done by (Gangrong *et al.*, 2014) on peanuts being carried out under different conditions. Some anatomical studies concerning mineral- and nano-Iron with different concentrations were achieved. (El-Desouky, 2017) found that there were an effect of Iron on the stems tissues such as thickness of xylem and phloem, stem, cambium, sclerenchyma tissues and pith. Concerning leaf anatomy, the thickness of spongy and palisade tissue, xylem tissues and the number of vessels and phloem this study was done on cucumber plant. There are only two studies concerning Moringa plant and Iron. (Abou-Shell *et al.*, 2017) studied the effect of Lithovit and Ca, Mg, and Fe nano particles. They noticed an increase in the tissues of stem and phloem thickness and dimensions of vessels. The second

study being conducted by (AbdulRahaman *et al.*, 2018) with three plants species included Moringa as affected by sodium azide and nitrous acid. Due to lack of information concerning Moringa plant where it is recently introduced to Iraq and due to its importance, work was conducted using mineral-and nano-Iron added either soil or foliar application.

### Materials and Methods

Pots experiment was carried out, using 15 kgs clay loam soil capacity pots arranged as a factorial experiment within C.R.D, with three replicates. Seeds of Moringa (*Moringa oleifera* Lam.) were sown in a plastic pots i.e. one seed per pot, on 21/3/2019. Samples from soils were taken before planting, and some chemical and physical properties were determined : EC=4.51 ds.m<sup>-1</sup>, PH = 7.29, available Iron =18.7 mg.kg<sup>-1</sup>, soil texture = clay loam.

The experiment was carried out in a private nursery, Kerbala province. Three factors were adopted i.e. method of application (soil or foliar), and three levels of mineral-Iron as FeSO<sub>4</sub>.7H<sub>2</sub>O (0,180 and 360) mg.l<sup>-1</sup> and three levels of nano-Iron (0,180 and 360) mg.l<sup>-1</sup>. The experiment was terminated on 20/10/2019.

#### Method of leaves anatomy :

The epidermis of fresh leaves was prepared, as collected from Moringa plants and immediately used in the preparation. Method of (Ahmad *et al.*, 2010) was adopted, the middle part of the leaf was cut into two halves at the midrib region one half was cleaned from tissues present underneath the epidermis.

#### Preparation of lower epidermis:

1. The prepared part is placed on the slide, Adaxial epidermis to the up and Abaxial epidermis to the down direction, upper and mesophyll tissues are removed by scrape carefully because the epidermis of this genus is thin, delicate and easy to destroy. During scraping, few drops of hot water were added every few minutes to keep the leaf fresh as long as possible.
2. Transfer the prepared part by forceps to the hot water for cleaning the remaining mesophyll tissue.
3. Placing the sample on a slide upside down for staining with safranin (1%) dissolved in 70% alcohol with washing using 70% alcohol.
4. Transfer into slide, with one drop of Glycerin covered by cover-slide, at this time the sample is ready for test.

#### Preparation of upper epidermis

The leaf blade is conversely placed to the first case of the previous steps were adopted. The slides were kept in the refrigerator at 4 °C till the checkup.

Properties being studied concerning Abaxial Epidermis of leaves of *Moringa oleifera*.

1. The number of stomatoes in the microscopic field, was recorded.
2. Stomato diameter, was measured.
3. 
$$\text{Stomato index (\%)} = \frac{\text{number of stomatoes}}{\text{number of stomatoes} + \text{number of epidermis cells}} \times 100$$
 (Royer, 2001).
4. The number of hairs in the microscopic field.
5. Length of hairs.

6. Length of epidermis cells.
7. Width of epidermis cells.
8. The number of epidermis cells in the microscopic field.

Studied properties of Adaxial epidermis of Moringa plant leaves.

1. Hairs number in the microscopic field.
2. Length of hairs.
3. Length of epidermis cells.
4. Width of epidermis cells.
5. The no of epidermis cells in the microscopic field.

Compound microscopes types Altay and Motic were used to measure parts and tissues and cells of epidermis. More than 40 microscopic fields were studied. The area of microscopic field at 40x power =158.96 μm. Epidermis of plant leaves were measured using Ocular ruler, photos of samples were directly taken from the microscope using Samsung Mobile camera type A7.

### Results and Discussion

#### The Lower Epidermis

The criteria of lower epidermis of Moringa leaves is multicells in terms of species containing normal epidermis with rippled walls, irregular in shape. The intensity of rippled walls is fluctuated which ranged from rippled to polygon with those cells increased in size. Whereas severe rippled was noticed with cells stayed without increase in size. The stomato was considered as a second type which was hypostomatic type (i.e. present on the lower epidermis only) but with this study it was recorded that stomatoes were found on the upper epidermis as well but with a low number. The type of guard cells were kidney shape, the stomatal complex was anomocytic and sometimes tetracytic or anisocytic as mentioned by (AbdulRahaman *et al.*, 2018). In this present study, in addition to the previously mentioned criteria, Actinocytic was recorded. The third type of epidermis is the hairs which they are unicellular, and their number on the lower epidermis is less than on the upper epidermis.

This study revealed that, an increase in the volume of normal cells of epidermis treated with different concentrations of mineral- and nano-Iron (Table 1 and Fig. 2). The highest increase was obtained from 360 mg.l<sup>-1</sup> nano-Iron with 360 mg.l<sup>-1</sup> mineral-Iron where cells were 41.75 μm in length and 17.75 μm in width compared with the control treatment which gave 35.22 μm length and 16.33 μm width. Soil application of Iron gave higher volume of normal cells than that obtained from foliar application treatment (Table 2 and Fig. 1). Soil application with 360 mg.l<sup>-1</sup> of mineral and nano-Iron gave 48.20 μm length and 21.80 μm width. It is worth mentioning that the increment in the cells volume is positively proportioned with the increment of leaf area (Kim *et al.*, 2015) who recorded 50% increase in leaf area as a result of increasing cells length or volume when nano-Iron was added to *Arabidopsis thaliana* plant. It should be pointed that, this study is considered the first study concerned with both upper and lower epidermis of Moringa plant affected by different levels of mineral and nano-Iron.

The same trend was found with stomatoes. The length value of stomatal diameter was obtained from 360 mg.l<sup>-1</sup> mineral and 360 mg.l<sup>-1</sup> nano-Iron (Table 2), where stomatal

diameter was 27.67  $\mu\text{m}$  compared with the control treatment which gave 23.75 $\mu\text{m}$ .

Foliar application with nano-and mineral-Iron at 360  $\text{mg.l}^{-1}$  gave higher stomatal diameter 26.50  $\mu\text{m}$  (Table 1). The increase in cells volume could be due to increasing the activity of  $\text{H}^+$ -ATPase enzyme of the plasma membrane in leaves leading to swell of guard cells by influx of  $\text{K}^+$  or  $\text{Na}^+$  and subsequently increase the cell volume (Kim *et al.*, 2015). The same finding was mentioned by (AbdulRahaman *et al.*, 2018) with Moringa plants subjected to Sodium azide and nitrous acid treatment. They attributed the increase of stomatoes volume to the increase of guard cell volume, this increment caused an increase in chloroplast or plastids in the guard cells leading to contain a large quantity of chlorophyll increasing ATP and active sugars. The number of stomatoes was also studied (Table 1). The same treatment 360 $\text{mg.l}^{-1}$  nano and 360  $\text{mg.l}^{-1}$  mineral-Iron gave the highest number of stomatoes (39 stomatoes ) in the microscopic field (40X).

Soil application with 360  $\text{mg.l}^{-1}$  and both nano- and mineral-iron gave higher number of stomatoes (38) compared with foliar application (Table 2).

Foliar application with 360  $\text{mg.l}^{-1}$  and 360  $\text{mg.l}^{-1}$  from both types of Iron gave higher value of stomatal index reached 17.80. Soil application with both types of Iron at 360  $\text{mg.l}^{-1}$  gave 20.77 stomatal index compared with the control (10.71). The number and length of the hairs on the lower epidermis was also studied. The highest number of hairs (5 hairs) was obtained from 180  $\text{mg.l}^{-1}$  nano-Iron without mineral-Iron, compared with hair obtained from the control treatment.

Soil application with 180  $\text{mg.l}^{-1}$  nano-Iron without mineral-Iron and 360  $\text{mg.l}^{-1}$  Iron from both types of treatments gave the highest number of hairs (4 hairs) compared with the control giving (2 hairs).

The length of hairs was higher from 360+360  $\text{mg.l}^{-1}$  Iron treatment giving 187 $\mu\text{m}$  (Table 2). Foliar application with 180  $\text{mg.l}^{-1}$  Iron from each gave a higher value 137  $\mu\text{m}$  compared with the control treatments which gave 113 $\mu\text{m}$  with the foliar application and 119.7 $\mu\text{m}$  with soil application. The Effect of Iron on the increasing length and hairs could be due to the induction of endogenous hormone levels such as Auxin which is responsible for the length of the cell (Sotiropoulos *et al.*, 2002).

**Table1:** The effect of foliar application with mineral- and nano-Iron on some properties of the lower epidermis of *Moringa oleifera* plant.

Treatments ( $\text{mg.l}^{-1}$ )	No. of stomatoes (40X)	stomatal diameter $\mu\text{m}$ (40X)	stomatal index %	No. of hairs (40X)	Length of hairs $\mu\text{m}$ (40X)	Length of epidermis cells $\mu\text{m}$ (40X)	Width of epidermis cells $\mu\text{m}$ (40X)	No. of epidermis cells (40X)
(0 nano+ 0 mineral)	19 (25) 30	20 (22.83) 27.5	10.59	0 (1) 2	77.5 (113) 170	20 (35.22) 47.5	12.5 (16.33) 25	163 (221) 284
(0 nano+180 mineral)	17 )26( 33	20 (21.5) 27.5	10.88	0 (2) 4	82.5 (113.25) 157.5	22.5 (36) 52.5	12.5 (17) 25	161 (213) 301
(0 nano+360 mineral)	25 (32) 36	17.5 (22) 27.5	12.22	0 (2) 4	82 (118) 165	22.5 (37.5) 52.5	10 (17.5) 32.5	173 (220) 317
(180 nano+0 mineral)	30 (33) 40	17.5 (22.5) 27.5	12.63	3 (5) 9	142.5 (130) 215	32.5 (35) 47.5	12.5 (16.5) 30	152 (232) 266
(180 nano+180 mineral)	28 (32) 39	20 (25.5) 27.5	12.85	1 (3) 5	77.5 (137) 205	25 (39.5) 42.5	12.5 (17.5) 22.5	137 (217) 345
(180 nano+360 mineral)	27 (34) 44	17.5 (22.5) 27.5	12.18	2 (3) 5	60 (107) 147	22.5 (36) 45	12.5 (17.5) 27.5	164 (245) 316
(360 nano+0 mineral)	27 (32) 40	20 (21) 27.5	11.27	0 (2) 3	77 (98) 165	22.5 (36.5) 42.5	12.5 (16.5) 20	171 (252) 321
(360 nano+180 mineral)	27 (35) 39	17.5 (20.5) 32.5	13.36	1 (3) 6	85 (134) 250	15 (37.5) 57.5	12.5 (16.5) 22.5	160 (225) 295
(360 nano+360 mineral)	27 (39) 45	20 (26.5) 30	17.80	0 (3) 5	75 (185) 245	17.5 (41.75) 57.5	12.5 (17.75) 20	137 (180) 270

**Table 2:** The effect of soil application with mineral- and nano-Iron on some properties of the lower epidermis of *Moringa oleifera* plant

Treatments (mg.l <sup>-1</sup> )	No. of stomatoes (40X)	stomatal diameter µm (40X)	stomatal index %	No. of hairs (40X)	Length of hairs µm (40X)	Length of epidermis cells µm (40X)	Width of epidermis cells µm (40X)	No. of epidermis cells (40X)
(0 nano+ 0 mineral)	20 (27) 32	20 (23.75) 27.5	10.71	1 (2) 6	42 (119.7) 145	17.5 (35.5) 37.5	12.5 (20.5) 25	171 (225) 263
(0 nano+180 mineral)	21 (28) 35	22.5 (20.5) 32.5	11.42	1 (2) 4	54 (97.5) 151	20.5 (34.36) 42	12.5 (20.90) 25	167 (217) 258
(0 nano+360 mineral)	21 (26) 31	20 (22.5) 27.5	9.81	1 (3) 6	100 (124) 209	22.5 (35.5) 52.5	10 (18.5) 27.5	148 (239) 291
(180 nano+0 mineral)	25 (30) 34	20 (25) 27.5	13.39	1 (4) 7	80 (142) 250	27.5 (40.25) 45	10 (20.5) 22.5	154 (194) 237
(180 nano+180 mineral)	22 (30) 37	20 (25.5) 27.5	14.09	1 (3) 6	80 (130.5) 192.5	27.5 (42.87) 50	12.5 (20.5) 30	145 (183) 281
(180 nano+360 mineral)	32 (35) 41	17.5 (26.5) 32.5	16.67	1 (3) 6	75 (136.5) 199	22.5 (45) 45	10 (18.5) 27.5	148 (239) 291
(360 nano+0 mineral)	25 (28) 35	20.5 (22.5) 27.5	11.49	1 (2) 3	87.5 (183) 200	27.5 (35.5) 40	15 (19) 25	141 (231) 268
(360 nano+180 mineral)	13 (35) 30	20 (27.5) 32.5	17.59	1 (3) 6	87.5 (134.25) 230	35 (46.5) 45	12.5 (20.5) 25	126 (164) 247
(360 nano+360 mineral)	25 (38) 42	20 (27.67) 32.5	20.77	1 (4) 7	115 (187) 250	30 (48.2) 55	15 (21.8) 27.5	120 (145) 230

### The upper epidermis

Upper epidermis consists of two kinds of cells normal epidermis with straight or curved walls and mostly having polygon shape that different from lower epidermis which has a distinguished criteria i.e. undulated walls. The upper epidermis doesn't contain stomatoes except some are present near the main midrib and margins. The second type of cells is the unicellular hairs. The number of hairs in the microscopic field showed an increase with the treatment 0 nano+ 180 mg.l<sup>-1</sup> mineral-Iron as foliar application giving 10 hairs (Table 3 and Fig. 4). On the other hand, 360 mg.l<sup>-1</sup> nano and 0 mineral-Iron as well as 360 mg.l<sup>-1</sup> nano + 360 mg.l<sup>-1</sup> mineral-Iron treatment gave the lowest (4 hairs). The treatment as soil application showed that 0 nano + 180 mg.l<sup>-1</sup> mineral-Iron and 360 mg.l<sup>-1</sup> nano + 180 mg.l<sup>-1</sup> mineral-Iron gave the highest values of hairs number (14 hairs) whereas, 0 nano + 360 mg.l<sup>-1</sup> mineral-Iron and 180 mg.l<sup>-1</sup> nano + 0 mineral-Iron gave the least value (4 hairs) (Table 4 and Fig. 3).

The length of hair was also affected by Iron treatments. Foliar application of 360 mg.l<sup>-1</sup> nano + 360 mg.l<sup>-1</sup> mineral-Iron gave higher length of hairs 144.75 µm whereas, 180 mg.l<sup>-1</sup> nano + 360 mg.l<sup>-1</sup> mineral-Iron gave the lowest length 70 µm (Table 3). Iron treatment as soil method 360 mg.l<sup>-1</sup> nano + 180 mg.l<sup>-1</sup> mineral-Iron gave the highest length of hairs reached 175 µm meanwhile, 0 nano + 180 mg.l<sup>-1</sup> mineral-Iron treatment gave the lowest length 88.75 µm (Table 4). Epidermal cells length as influenced by foliar application of Iron showed that 360 mg.l<sup>-1</sup> nano + 360 mg.l<sup>-1</sup> mineral-Iron as foliar application gave higher value 47 µm compared with the control giving 36.83 µm (Table 3). The

same trend was found with the soil application giving 50.4 µm and 34.5µm for the highest-concs. and the control respectively (Table 4).

The width of epidermal cells was also affected by Iron treatments. Foliar application of nano-Iron at 360 mg.l<sup>-1</sup> +360 mg.l<sup>-1</sup> mineral-Iron gave the highest width 30 µm whereas, the control treatment gave the lowest width 22.83µm (Table 3). Iron treatment as soil application of nano-Iron at 180mg.l<sup>-1</sup> +0 mineral-Iron and 360 nano+360 mineral-iron gave the highest values 30.5 µm, mean while 360 nano+0 mineral-iron gave the lowest 21.5 µm (Table 4).

The number of epidermal cells in the microscopic field (40x) was influenced by Iron concentrations and methods of application. Foliar application of nano 180+ 0 mineral-iron gave higher number of epidermal cell reached 210 cells whereas, the highest concentration of both types of Iron gave the lowest number 168 cells ( Table 3). Soil application and treatment affected the number of epidermal cells as well as where control treatment gave the highest number 229 cells meanwhile the highest concs. of Iron gave the lowest number 172 cells (Table 4). (AbdulRahaman *et al.*, 2018) found an increase number of hairs on the lower epidermis in contrast to the upper epidermis where there was a reduction in the number of hairs, it is believed that the number of hairs is highly related with the stomatal presence and temperature. The study of (Agamy, 2004; Abbas, 2013; El-Desouky, 2017) could explain the increment in the number and length of cells of normal epidermal cells, stomatoes and hairs. Foliar application of Iron increased the efficiency of cambium leading to affect levels of phytohormones especially Cytokinins which is responsible on the increase of cells

number, and Auxins which are responsible on the elongation of cells consequently increase the leaf area, vegetative growth, the fresh and dry weight, plant height, leaves number and branches.

**Table 3:** The effect of foliar application with mineral- and nano-Iron on some properties of the upper epidermis of *Moringa oleifera* plant.

Treatments (mg.l <sup>-1</sup> )	No. of hairs (40X)	Length of hairs μm (40X)	Length of epidermis μm (40X)	Width of epidermis cells μm (40X)	No. of epidermis cells (40X)
(0 nano+ 0 mineral)	7	60	25	17.5	161
	(9)	(85)	(36.83)	(22.83)	(206)
	13	117.5	42	27.5	296
(0 nano+180 mineral)	6	55	22.5	17.5	168
	(10)	(89)	(41)	(26.5)	(180)
	13	110	57.5	42.5	206
(0 nano+360 mineral)	4	90	35	20	158
	(7)	(113)	(41.7)	(27)	(178)
	10	155	50	42.5	199
(180 nano+0 mineral)	5	67.5	30	17.5	128
	(9)	(90.5)	(37.5)	(23.5)	(210)
	13	117.5	50	37.5	225
(180 nano+180 mineral)	3	60	27.5	12.5	153
	(7)	(89)	(38)	(25)	(195)
	8	102.5	55	32	254
(180 nano+360 mineral)	6	25.5	30	20	163
	(8)	(70)	(40.5)	(23)	(184)
	12	115	62.5	37	218
(360 nano+0 mineral)	2	40	30	22.5	151
	(4)	(72.25)	(41)	(25)	(187)
	7	125	55	35	216
(360 nano+180 mineral)	6	82.5	35	22.5	160
	(8)	(131)	(39.5)	(25)	(195)
	11	192.5	50.5	32.5	219
(360 nano+360 mineral)	2	60.5	30	22.5	150
	(4)	(144.75)	(47)	(30)	(168)
	7	178.5	62.5	37.5	193

**Table 4:** The effect of soil application with mineral- and nano-Iron on some properties of the upper epidermis of *Moringa oleifera* plant.

Treatments (mg.l <sup>-1</sup> )	No. of hairs (40X)	Length of hairs μm(40X)	Length of epidermis μm (40X)	Width of epidermis cells μm (40X)	No. of epidermis cells (40X)
(0 nano+ 0 mineral)	6	65	17.5	12.5	168
	(10)	(95.4)	(34.5)	(22.5)	(229)
	17	130	42.5	25	306
(0 nano+180 mineral)	10	67	25	15	142
	(14)	(88.75)	(35.75)	(23)	(205)
	19	105	47.5	27.5	252
(0 nano+360 mineral)	2	65	27.5	15	165
	(4)	(98.75)	(37.5)	(22.5)	(198)
	6	130	47.5	27.5	276
(180 nano+0 mineral)	2	57.5	27.5	22.5	160
	(4)	(103.75)	(42)	(30.5)	(182)
	6	120	52.5	37.5	203
(180 nano+180 mineral)	3	60	25	12.5	175
	(5)	(101.5)	(43.5)	(26.5)	(179)
	6	117	47.5	37.5	228
(180 nano+360 mineral)	5	77.5	20	17.5	183
	(9)	(120.25)	(45.75)	(25.5)	(195)
	11	150	50	30	237
(360 nano+0 mineral)	4	65	30	15	171
	(7)	(99)	(36.5)	(21.5)	(208)
	10	180	50	30	235
(360 nano+180 mineral)	7	70	32.5	17.5	168
	(14)	(175)	(47)	(27)	(180)
	19	250	57.5	35	220
(360 nano+360 mineral)	2	65	35	17.5	150
	(5)	(164.5)	(50.4)	(30.5)	(172)
	7	200	65	37.5	206

In general, concerning the influence of soil and foliar application comparison, the general mean of epidermis properties was calculated irrespective of Iron concentration (Table 5). Data in the table (5) revealed that apart from two cases (i.e. the number of stomatoes and epidermal cells) all remaining properties recorded higher values from soil application with lower and upper epidermis. The reason for

this finding could be attributed to the time of nutrient availability. The time of nutrient absorption by leaves is too short according to the evaporation of water from the leaf surface. On the other hand, most nutrients in the soil are available, slowly released to face the demand of plants, this would happen because of the soil buffering capacity.

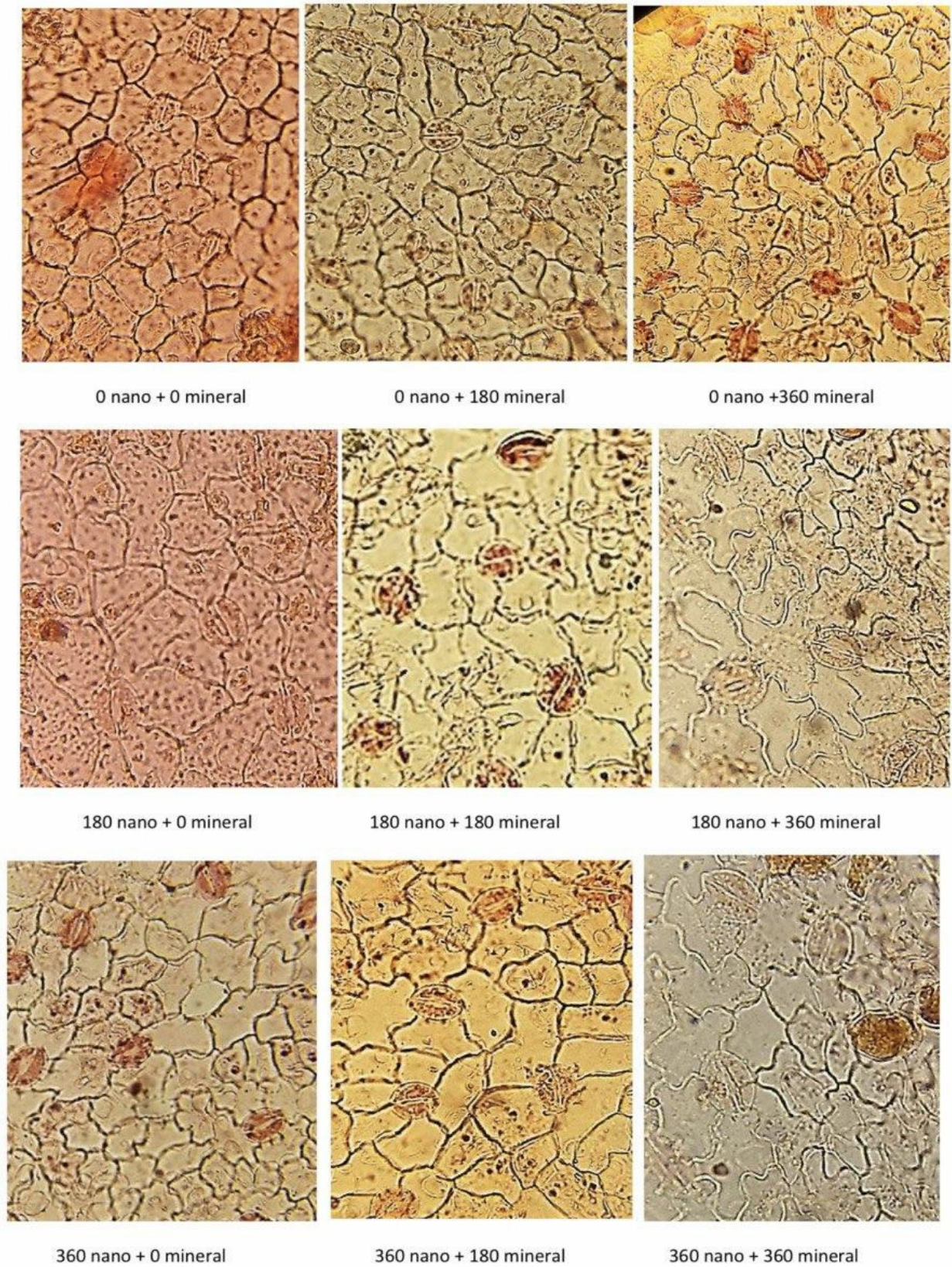
**Table 5:** General means of lower and upper epidermis properties as an influence by soil or foliar Iron application

Epidermis properties	Soil application	Foliar application
<b>Lower epidermis</b>		
Number of stomatoes	30.8	32.0
Diameter of stomatoes $\mu\text{m}$	24.6	22.8
Length of stomatoes $\mu\text{m}$	14.0	12.6
Number of hairs	2.9	2.7
Length of hairs $\mu\text{m}$	139.1	126.1
Length of epidermal cells $\mu\text{m}$	40.4	37.5
Width of epidermal cells $\mu\text{m}$	20.1	17.0
Number of epidermal cells $\mu\text{m}$	204.1	222.8
<b>Upper epidermis</b>		
Number of hairs	8.0	7.3
Length of hairs $\mu\text{m}$	116.3	98.3
Length of epidermal cells $\mu\text{m}$	41.4	40.3
Width of epidermal cells $\mu\text{m}$	25.5	25.3
Number of epidermal cells $\mu\text{m}$	194.2	189.2

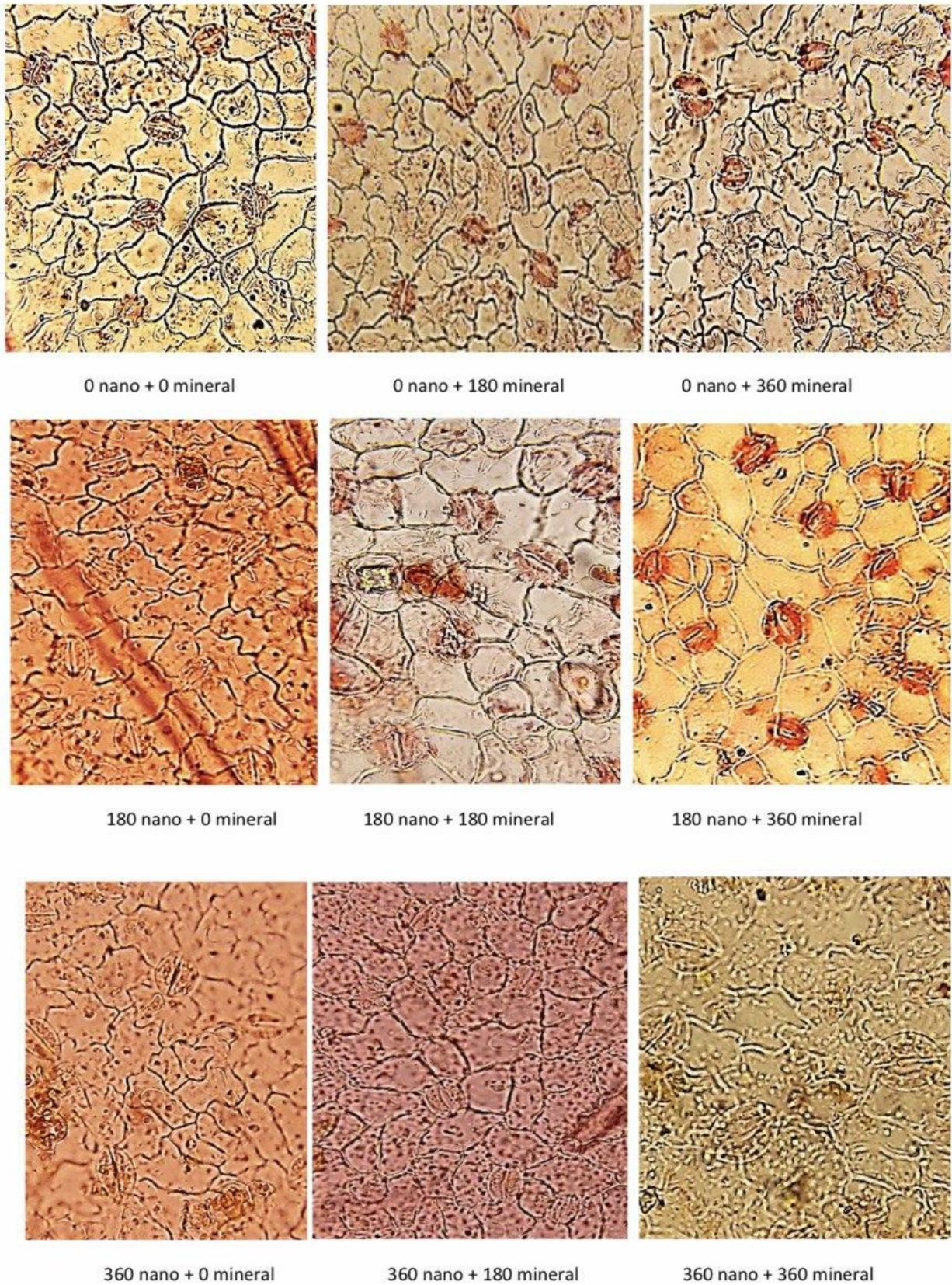
### Conclusion

The application method caused an increase in the mean dimensions of normal epidermis cells, stomatoes, and hairs. These traits were increased as Iron levels increased. Soil application gave higher values of epidermis dimensions

than that obtained from the foliar application. The number of stomatoes increased with increasing the level of Iron. The number of normal epidermis cells was conversely proportioned with their volume.

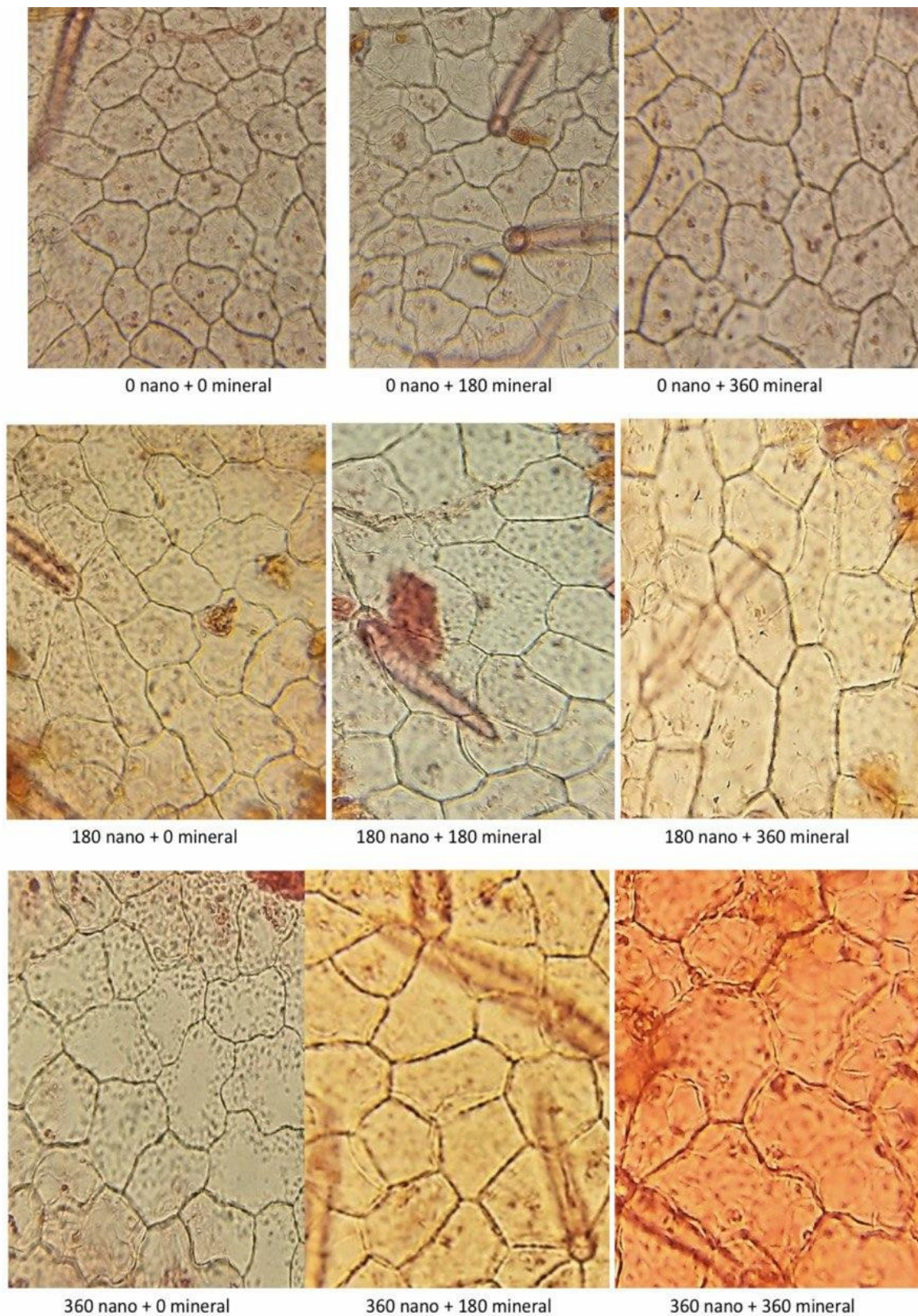


**Fig(1):**the variation in dimentions of lower leaves epidermis cells of *Moriga* plant as influenced by soil application of mineral and nano –Iron.

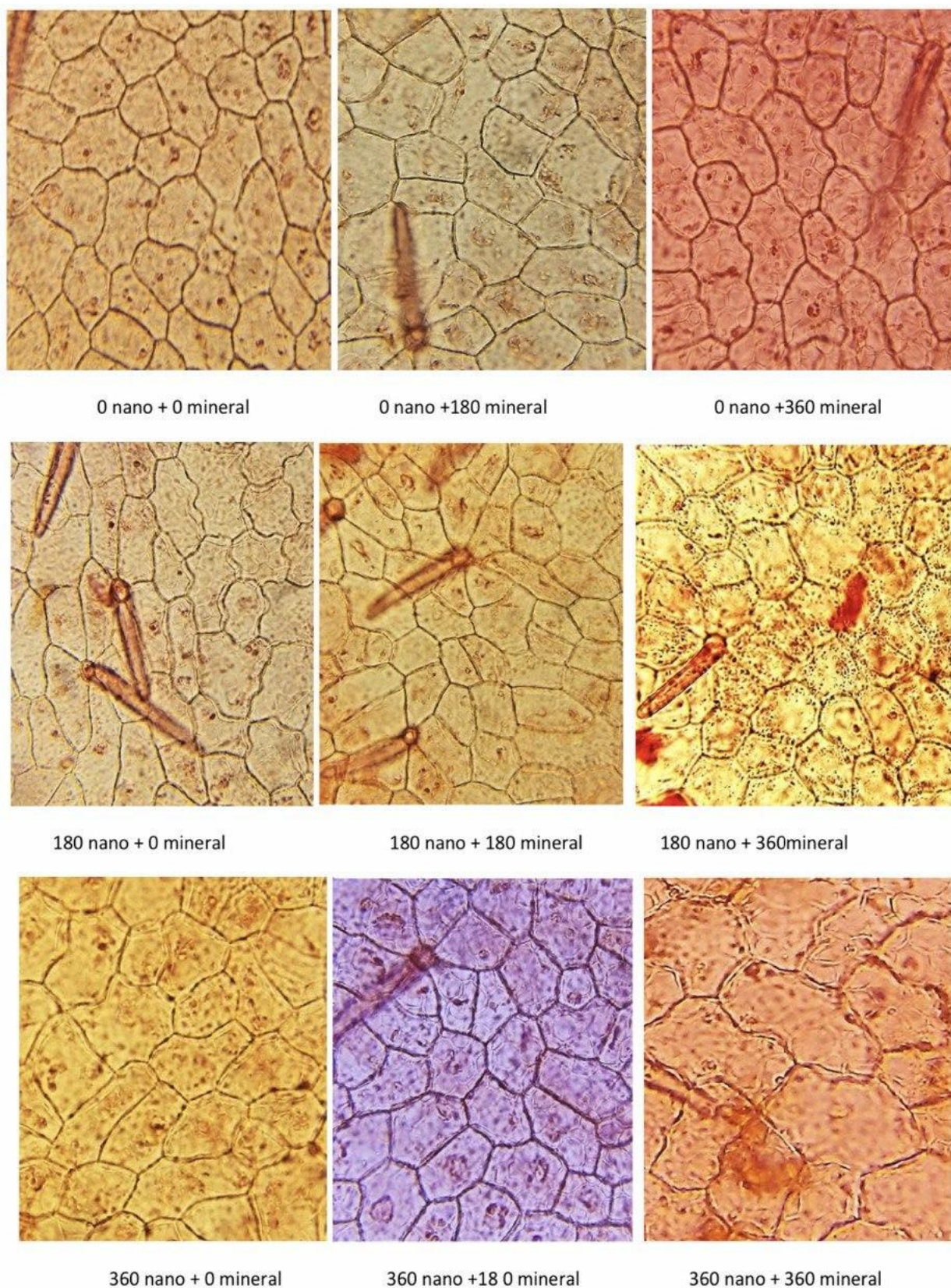


**Fig(2):**the variation in dimentions of lower leaves epidermis cells of *Moriga* plant as influenced by foliar application of mineral and nano –Iron.





**Fig(3):**the variation in dimentions of upper leaves epidermis cells of *Moriga* plant as influenced by soil application of mineral and nano –Iron.



**Fig(4):**the variation in dimentions of upper leaves epidermis cells of *Moriga* plant as influenced by foliar application of mineral and nano –Iron.

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