



Suez Canal University  
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# Effect of Nano-Particle Fertilizers on Growth, Seed Yield and Active Constituents of *Silybum Marianum* Plant

BY

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<b>English Abstract</b>	
<p>The experimental work was conducted at the Experimental Farm of Ismailia Agriculture Research Station, Ismailia Governorate Egypt, to study the effect of iron ( 0.0, 7.5, 15 and 30 ppm) from Fe<sub>3</sub>O<sub>4</sub>-NPs, Zn (0.0, 0.25, 0.50 and 1.00 g/liter) from ZnO-NPs and Titanium Dioxide TiO<sub>2</sub>-NPs (0.0, 0.25, 0.50 and 1.00 g/liter) as well as treated of seeds pre-sowing for 0, 5, 10- and 15-minutes to He-Ne Laser Irradiation on growth, seed yield and active constituents of <i>Silybum marianum</i> plants during the two successive seasons of 2018 / 2019 and 2019 / 2020. All experiments were designed as randomized complete blocks design with three replicates. This work included four experiments: The most important results could be summarized as follows: Spraying <i>Silybum marianum</i> plants with Fe<sub>3</sub>O<sub>4</sub>-NPs at 30 ppm, ZnO-NPs at 1 g/l or TiO<sub>2</sub>-NPs at 1 g/l twice, firstly before flowering stage in 9<sup>th</sup> of February and secondly, after flowering stage in 9<sup>th</sup> of March in the two seasons. Also, irradiation of <i>Silybum marianum</i> seeds with He-Ne laser radiation (4 mW) for 15 minutes before sowing increased vegetative growth parameters, number of inflorescences/plant, dry weight of roots, herb and inflorescences/plant, seed yield/feddan., TXF, SDN, SBN, SCN, ISBN, total silymarin in fruits, chlorophyll a, chlorophyll b, total chlorophyll a+b, N, P and K contents in leaves, Fe, Zn and Ti concentrations in fruits.</p>	
<p>Key Words: <i>Silybum marianum</i>, Fe<sub>3</sub>O<sub>4</sub>-NPs, ZnO-NPs, TiO<sub>2</sub>-NPs, He-Ne Laser Irradiation, Vegetative growth, Silymarin and seed yield.</p>	

## CONTENTS

Chapter	Page No.
<b>1. INTRODUCTION</b>	1
<b>2. REVIEW OF LITERATURE</b>	5
<b>3. MATERIALS AND METHODS</b>	32
<b>4. RESULTS AND DISCUSSION</b>	41
<b>4.1. Effect of foliar spray with iron oxide nanoparticles (Fe<sub>3</sub>O<sub>4</sub>-NPs) on growth, photosynthetic pigments, seed yield and active ingredients of <i>Silybum marianum</i></b>	41
4.1.1. Vegetative characters	41
4.1.2. Root system	42
4.1.3 Dry weight	43
4.1.4. Leaf pigments	45
4.1.5. Seed yield	47
4.1.6. Active ingredients in fruits	50
4.1.7. Chemical composition	52
<b>4.2. Effect of zinc oxide nanoparticles (ZnO-NPs) as foliar application on growth, photosynthetic pigments, seed yield and active ingredients of <i>Silybum marianum</i></b>	54
4.2.1. Vegetative characters	54
4.2.2. Root system	56

4.2.3 Dry weight	57
4.2.4. Leaf pigments	59
4.2.5. Seed yield	61
4.2.6. Active ingredients in fruits	64
4.2.7. Chemical composition	66
<b>4.3. Effect of titanium dioxide Nanoparticles (TiO<sub>2</sub>-NPs) as foliar application on growth, photosynthetic pigments, seed yield and active ingredients of <i>Silybum marianum</i></b>	69
4.3.1. Vegetative characters	69
4.3.2. Root system	71
4.3.3 Dry weight	72
4.3.4. Leaf pigments	73
4.3.5. Seed yield	76
4.3.6. Active ingredients in fruits	78
4.3.7. Chemical composition	80
<b>4.4. Effect of helium neon (He-Ne) laser irradiation of seeds on growth, photosynthetic pigments, seed yield and active ingredients of <i>Silybum marianum</i></b>	82
4.4.1. Vegetative characters	82
4.4.2. Root system	84
4.4.3 Dry weight	85

4.4.4. Leaf pigments	87
4.4.5. Seed yield	89
4.4.6. Active ingredients in fruits	92
4.4.7. Chemical composition	94
<b>5. SUMMARY AND CONCLUSION</b>	96
<b>6. LITERATURE CITED</b>	104
<b>ARABIC SUMMARY</b>	

## LIST OF TABLES

Table No.	Title	Page No.
1	The experimental soil in the two seasons was sandy soil and its characteristics	32
2	Chemical characteristics of the water used for irrigation of <i>Silybum marianum</i> L.	33
3	Effect of foliar spray with iron oxide nanoparticles concentrations on vegetative growth characters of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	42
4	Effect of foliar spray with iron oxide nanoparticles concentrations on root parameters of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	42
5	Effect of foliar spray with iron oxide nanoparticles concentrations on dry weight of <i>Silybum marianum</i> organs during 2018/2019 and 2019/2020 seasons under sandy soil conditions	44
6	Effect of foliar spray with iron oxide nanoparticles concentrations on leaf pigments (mg /100g FW) of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	46
7	Effect of foliar spray with iron oxide nanoparticles concentrations on seeds yield of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	48
8	Effect of foliar spray with iron oxide nanoparticles concentrations on active constituents of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	50

9	Effect of foliar spray with iron oxide nanoparticles concentrations on N, P and K contents in leaves as well as Fe concentrations in fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	53
10	Effect of foliar spray with zinc oxide nanoparticles concentrations on vegetative growth characters of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	56
11	Effect of foliar spray with zinc oxide nanoparticles concentrations on root parameters of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	57
12	Effect of foliar spray with zinc oxide nanoparticles concentrations on dry weight of <i>Silybum marianum</i> organs during 2018/2019 and 2019/2020 seasons under sandy soil conditions	58
13	Effect of foliar spray with zinc oxide nanoparticles concentrations on leaf pigments (mg /100g FW) of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	59
14	Effect of foliar spray with zinc oxide nanoparticles concentrations on seeds yield of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	61
15	Effect of foliar spray with zinc oxide nanoparticles concentrations on active constituents of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	64
16	Effect of foliar spray with zinc oxide nanoparticles concentrations on N, P and K contents in leaves as well as Zn concentrations in fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	67

17	Effect of foliar spray with titanium dioxide nanoparticles concentrations on vegetative growth characters of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	70
18	Effect of foliar spray with titanium dioxide nanoparticles concentrations on root parameters of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	71
19	Effect of foliar spray with titanium dioxide nanoparticles concentrations on dry weight of <i>Silybum marianum</i> organs during 2018/2019 and 2019/2020 seasons under sandy soil conditions	73
20	Effect of foliar spray with titanium dioxide nanoparticles concentrations on leaf pigments (mg/100g FW) of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	75
21	Effect of foliar spray with titanium dioxide nanoparticles concentrations on seeds yield of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	76
22	Effect of foliar spray with titanium dioxide nanoparticles concentrations on active constituents of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	79
23	Effect of foliar spray with titanium dioxide nanoparticles concentrations on N, P and K contents in leaves as well as Ti concentrations in fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	81
24	Effect of laser irradiation of seeds on vegetative growth characters of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	84



25	Effect of laser irradiation of seeds on root parameters of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	85
26	Effect of laser irradiation of seeds on dry weight of <i>Silybum marianum</i> organs during 2018/2019 and 2019/2020 seasons under sandy soil conditions	86
27	Effect of laser irradiation of seeds on leaf pigments (mg /100g FW) of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	87
28	Effect of laser irradiation of seeds on seeds yield of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	90
29	Effect of laser irradiation of seeds on active constituents of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	93
30	Effect of laser irradiation of seeds on N, P and K contents in leaves of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	94

## LIST OF FIGUERS

Figuer No.	Title	Page No.
1	TEM imaging of the prepared Fe nanoparticles revealed a spherical shape of the particles, with an average size of 100 nm (inset shows electron diffraction pattern)	35
2	TEM imaging of the prepared Zn nanoparticles revealed a spherical shape of the particles, with an average size of 100 nm (inset shows electron diffraction pattern)	36
3	TEM imaging of the prepared Ti nanoparticles revealed a spherical shape of the particles, with an average size of 100 nm (inset shows electron diffraction pattern)	37
4	Effect of foliar spray with iron nanoparticles concentrations on total chlorophyll in leaves of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	46
5	Effect of foliar spray with iron nanoparticles concentrations on yield of seeds of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	49
6	Effect of foliar spray with iron nanoparticles concentrations on Relative increases in total yield /feddan (%) over control treatment of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	49
7	Effect of foliar spray with iron nanoparticles concentrations in total Silymarin (%) in dry fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	51
8	Effect of foliar spray with iron nanoparticles concentrations on Fe concentrations in dry fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	53

9	Effect of foliar spray with zinc oxide nanoparticles concentrations on total chlorophyll in leaves of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	60
10	Effect of foliar spray with zinc oxide nanoparticles concentrations on yield of seeds of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	62
11	Effect of foliar spray with zinc oxide nanoparticles concentrations on Relative increases in total yield /feddan (%) over control treatment of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	62
12	Effect of foliar spray with zinc oxide nanoparticles concentrations in total Silymarin (%) in dry fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	65
13	Effect of foliar spray with zinc oxide nanoparticles concentrations on Zn concentrations in dry fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	67
14	Effect of foliar spray with titanium dioxide nanoparticles concentrations on total chlorophyll in leaves of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	75
15	Effect of foliar spray with titanium dioxide nanoparticles concentrations on yield of seeds of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	77

16	Effect of foliar spray with titanium dioxide nanoparticles concentrations on relative increases in total yield /feddan (%) over control treatment of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	77
17	Effect of foliar spray with titanium dioxide nanoparticles concentrations in total Silymarin (%) in dry fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	79
18	Effect of foliar spray with titanium dioxide nanoparticles concentrations on Ti concentrations in dry fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	81
19	Effect of laser irradiation of seeds on total chlorophyll in leaves of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	88
20	Effect of laser irradiation of seeds on yield of seeds of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	90
21	Effect of laser irradiation of seeds on relative increases in total yield /feddan (%) over control treatment of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	91
22	Effect of laser irradiation of seeds on total Silymarin (%) in dry fruits of <i>Silybum marianum</i> during 2018/2019 and 2019/2020 seasons under sandy soil conditions	93

## 5. SUMMARY AND CONCLUSION

The experimental work was conducted at the Experimental Farm of Ismailia Agriculture Research Station, Ismailia Governorate Egypt, to study the effect of iron (0.0, 7.5, 15 and 30 ppm) from Fe<sub>3</sub>O<sub>4</sub>-NPs, Zinc (0.0, 0.25, 0.50 and 1.00 g/liter) from ZnO-NPs and Titanium (0.0, 0.25, 0.50 and 1.00 g/liter) from TiO<sub>2</sub>-NPs as well as treated of seeds pre-sowing for 0, 5, 10 and 15-minutes to He-Ne Laser Irradiation on growth, seed yield and active constituents of *Silybum marianum* during the two successive seasons of 2018 / 2019 and 2019 / 2020.

All experiments were designed as randomized complete blocks design with three replicates. This work included four experiments as follows:

### **5.1. Effect of foliar spray with iron oxide nanoparticles (Fe<sub>3</sub>O<sub>4</sub>-NPs) on growth, photosynthetic pigments, seed yield and active ingredients of *Silybum marianum***

1. Treating of *Silybum marianum* with iron oxide nanoparticles (Fe<sub>3</sub>O<sub>4</sub>-NPs) at different concentrations 7.5, 15 and 30 ppm significantly increased plant height, number of leaves/plant, number of inflorescences/plant and stem diameter at 150 days after sowing. Root length and number of roots/plant of *Silybum marianum* at 150 days after sowing increased with increasing Fe<sub>3</sub>O<sub>4</sub>-NPs up to 30 ppm in both seasons.

2. Spraying *Silybum marianum* with Fe<sub>3</sub>O<sub>4</sub>-NPs at 30 ppm increased dry weight of roots, herbs, inflorescences and total dry weight/plant followed by Fe<sub>3</sub>O<sub>4</sub>-NPs at 15 ml/l in both seasons. The increases in total dry weight/plant were about 80.6 and 93.2 % for spraying with Fe<sub>3</sub>O<sub>4</sub>-NPs at 30 ppm, 57.6 and 72.3 % for spraying with Fe<sub>3</sub>O<sub>4</sub>-NPs at 15 ppm and 19.4 and 46.5 % for spraying with Fe<sub>3</sub>O<sub>4</sub>-NPs at 7.5 ppm over unsprayed plants in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

2. Chlorophyll a, Chlorophyll b and total chlorophyll (a+b) concentrations in leaf tissues of *Silybum marianum* increased with increasing Fe<sub>3</sub>O<sub>4</sub>-NPs up to 30 ppm.
3. Treating *Silybum marianum* with Fe<sub>3</sub>O<sub>4</sub>-NPs at 30 ppm increased seed weight/plant, seed weight/plot and seed weight/fed. followed by treating with Fe<sub>3</sub>O<sub>4</sub>-NPs at 15 ppm in both seasons. The increases in total seed weight/fed. were about 27.1 and 47.3 % for spraying with Fe<sub>3</sub>O<sub>4</sub>-NPs at 30 ppm, 11.9 and 18.2 % for spraying with Fe<sub>3</sub>O<sub>4</sub>-NPs at 15 ppm and 12.0 and 11.8 % for spraying with Fe<sub>3</sub>O<sub>4</sub>-NPs at 7.5 ppm over unsprayed plants in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.
4. Silymarin components in the fruits (TXF, SDN, SBN, SCN, ISBN) and total silymarin of *Silybum marianum* increased with treating with Fe<sub>3</sub>O<sub>4</sub>-NPs at 30 ppm as foliar application in both seasons.
5. Contents of N, P and K in leaves as well as Fe in fruits of *Silybum marianum* significantly increased with increasing Fe<sub>3</sub>O<sub>4</sub>-NPs up to 30 ppm. On the other hand, the lowest values of N, P and K contents in leaves and Fe concentrations in fruits were recorded by control plants.

It could be concluded that, spraying *Silybum marianum* plants with Fe<sub>3</sub>O<sub>4</sub>-NPs at 30 ppm increased plant height, number of leaves/plant, number of inflorescences/plant, stem diameter, root length, number of roots/plant, dry weight of roots, herb and inflorescences/plant, chlorophyll a, chlorophyll b, total chlorophyll a+b, seed yield/fed., TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits, N, P and K contents in leaves and Fe concentrations in fruits in both seasons.

## **5.2. Effect of zinc oxide nanoparticles (ZnO-NPs) as foliar application on growth, photosynthetic pigments, seed yield and active ingredients of *Silybum marianum*.**

1. Spraying *Silybum marianum* plants with zinc oxide nanoparticles (ZnO-NPs) had significant effect on plant height, number of leaves/plant, number

of inflorescences/plant and stem diameter at 150 days after sowing compared to control plants in both seasons. Morphological characters increased with the increasing of ZnO-NPs up to 1 g/l, root length and number of roots/plant, dry weight of roots, herb and inflorescences/plant and total dry weight/plant. The increases in total dry weight/plant were about 44.2 and 93.9 % for spraying with ZnO-NPs at 1 g/l, 30.6 and 78.9 % for spraying with ZnO-NPs at 0.5 g/l and 18.0 and 10.5 % for spraying with ZnO-NPs at 0.25 g/l over unsprayed plants in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

2. Leaf pigments (Chlorophyll a, Chlorophyll b and total chlorophyll a+b) in leaf tissues of *Silybum marianum* plants increased with increasing ZnO-NPs up to 1 g/l.

3. Foliar spray of *Silybum marianum* plants with ZnO-NPs at 1 g/l significantly increased seed weight/plant, seed weight/plot and seed weight/fed. in both seasons followed by ZnO-NPs at 0.5 g/l. The increases in total seed weight/fed. were about 62.6 and 48.9 % for spraying with ZnO-NPs at 1 g/l, 20.0 and 36.6% for spraying with ZnO-NPs at 0.5 g/l and 19.1 and 11.1 % for spraying with ZnO-NPs at 0.25 g/l over unsprayed plants in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

4. Silymarin components increased with increasing ZnO-NPs up to 1 g/l. This means that ZnO-NPs at 1 g/l increased TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits.

5. Control treatments gave the lowest values of N, P and K contents in leaves and Zn concentrations in fruits followed by spraying with ZnO-NPs at 0.25 g/l.

It could be concluded that, treating *Silybum marianum* plants with ZnO-NPs at 1 g/l as foliar spray increased plant height, number of leaves/plant, root length, dry weight of roots, herb and inflorescences/plant,

total leaf chlorophyll, seed yield/fed., TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits, N, P and K contents in leaves and Zn concentrations in fruits.

### **5.3. Effect of Titanium Dioxide Nanoparticles (TiO<sub>2</sub>-NPs) as foliar application on growth, photosynthetic pigments, seed yield and active ingredients of *Silybum marianum*.**

1. Spraying *Silybum marianum* plants with Titanium dioxide Nanoparticles (TiO<sub>2</sub>-NPs) had significant effect on plant height, number of leaves/plant, number of inflorescences/plant and stem diameter at 150 days after sowing compared to control plants in both seasons. Morphological characters increased with the increasing of TiO<sub>2</sub>-NPs up to 1 g/l, root length and number of roots/plant, dry weight of roots, herb and inflorescences/plant and total dry weight/plant. The increases in total dry weight/plant were about 50.7 and 81.5 % for spraying with TiO<sub>2</sub>-NPs at 1 g/l, 49.1 and 67.4 % for spraying with TiO<sub>2</sub>-NPs at 0.5 g/l over unsprayed plants in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

2. Chlorophyll a, Chlorophyll b and total chlorophyll in leaf tissues of *Silybum marianum* plants significantly increased with increasing TiO<sub>2</sub>-NPs up to 1 g/l. Treating *Silybum marianum* plants with TiO<sub>2</sub>-NPs at different concentrations had significant effect on leaf pigments compared to control plants in both seasons.

3. Spraying *Silybum marianum* plants with TiO<sub>2</sub>-NPs at 1 g/l significantly increased seed weight/plant, seed weight/plot and seed weight/fed and TiO<sub>2</sub>-NPs at 0.25, 0.5 and 1.0 g/l increased these traits compared to control in both seasons. The increases in total seed weight/fed. were about 49.6 and 67.0 % for spraying with TiO<sub>2</sub>-NPs at 1 g/l, 46.8 and 45.9 % for spraying



with TiO<sub>2</sub>-NPs at 0.5 g/l and 32.6 and 20.5 % for spraying with TiO<sub>2</sub>-NPs at 0.25 g/l over unsprayed plants in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

4. Taxifolin (TXF), Silydianin (SDN), Silybin (SBN), Silychristin (SCN) and Iso silybin (ISBN) and total silymarin in fruits were the maximum with spraying *Silybum marianum* plants with TiO<sub>2</sub>-NPs at 1 g/l significantly increased, followed by spraying *Silybum marianum* plants with TiO<sub>2</sub>-NPs at 0.5 g/l and foliar spray with TiO<sub>2</sub>-NPs at different concentrations increased TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits compared to control treatment in both seasons.

5. TiO<sub>2</sub>-NPs at 1 g/l increased N, P and K contents in leaves and Ti concentrations in fruits of *Silybum marianum* plants followed by TiO<sub>2</sub>-NPs at 0.5 g/l in both seasons. Control treatment gave the lowest values of N, P and K contents in leaves and Ti concentrations in fruits followed by spraying with TiO<sub>2</sub>-NPs at 0.25 g/l.

It could be concluded that, spraying *Silybum marianum* plants grown in sandy soil with TiO<sub>2</sub>-NPs at 1 g/l increased plant height, number of leaves/plant, number of inflorescences/plant, stem diameter, dry weight of roots, herb and inflorescences/plant, number of roots/plant, total leaf chlorophyll, seed yield/fed., TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits, N, P and K contents in leaves and Ti concentrations in fruits.

#### **5.4. Effect of helium neon (He-Ne) laser irradiation of seeds on growth, photosynthetic pigments, seed yield and active ingredients of *Silybum marianum*.**

1. Helium neon (He-Ne) laser irradiation of seeds for 15 minutes gave the tallest plants and recorded maximum values of number of leaves/plant and

stem diameter, number of inflorescences/plant, root length and number of roots/plant, dry weight of roots, herb, inflorescences/plant and total dry weight/plant followed by irradiation of seeds for 10 minutes in both seasons. The increases in total dry weight/plant were about 27.1 and 23.7 % for irradiation of seeds by He-Ne laser for 15 minutes, 19.6 and 15.8 % for 10 minutes and 7.7 and 4.5 % for 5 minutes over unsprayed plants in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

2. Chlorophyll a, Chlorophyll b and total chlorophyll (a+b) concentrations in leaf tissues of *Silybum marianum* plants significantly increased with increasing irradiation time of He-Ne laser up to 15 minutes.

3. Irradiation time of *Silybum marianum* seeds for 15 minutes with He-Ne significantly increased seed weight/plant, seed weight/plot and seed weight/fed. followed by irradiation time for 10 minutes in both seasons. Control treatment (without irradiation) gave the lowest values of seed yield compared to other treatments in both seasons. The increases in total seed yield/fed. were about 51.3 and 14.7 % for irradiation of seeds by He-Ne laser for 15 minutes, 28.2 and 8.6 % for 10 minutes and 2.5 and 7.4 % for 5 minutes over unsprayed plants in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

4. He-Ne laser irradiation of *Silybum marianum* seeds for 15 minutes significantly increased TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits followed by irradiation for 10 minutes.

5. Nitrogen, P and K contents in leaves of *Silybum marianum* plants significantly increased with increasing irradiation time of He-Ne laser up to 15 minutes.

It could be concluded that, irradiation of *Silybum marianum* seeds with He-Ne laser radiation (4 mW) for 15 minutes before sowing increased

plant height, number of leaves/plant, root length, number of roots/plant, dry weight of different plants parts, total leaf chlorophyll, seed yield/fed., TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits, N, P and K contents in leaves.

### **Recommendations:**

It could be seen that:

1. Spraying *Silybum marianum* plants with Fe<sub>3</sub>O<sub>4</sub>-NPs at 30 ppm increased plant height, number of leaves/plant, number of inflorescences/plant, stem diameter, root length, number of roots/plant, dry weight of roots, herb and inflorescences/plant, chlorophyll a, chlorophyll b, total chlorophyll a+b, seed yield/fed., TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits, N, P and K contents in leaves and Fe concentrations in fruits.
2. Treating *Silybum marianum* plants with ZnO-NPs at 1 g/l as foliar spray increased plant height, number of leaves/plant, root length, dry weight of roots, herb and inflorescences/plant, total leaf chlorophyll, seed yield/fed., TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits, N, P and K contents in leaves and Zn concentrations in fruits.
3. Spraying *Silybum marianum* plants grown in sandy soil with TiO<sub>2</sub>-NPs at 1 g/l increased plant height, number of leaves/plant, number of inflorescences/plant, stem diameter, dry weight of roots, herb and inflorescences/plant, number of roots/plant, total leaf chlorophyll, seed yield/fed., TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits, N, P and K contents in leaves and Ti concentrations in fruits.
4. Irradiation of *Silybum marianum* seeds with He-Ne laser radiation (4 mW) for 15 minutes before sowing increased plant height, number of

leaves/plant, root length, number of roots/plant, dry weight of different plants parts, total leaf chlorophyll, seed yield/fed., TXF, SDN, SBN, SCN, ISBN and total silymarin in fruits, N, P and K contents in leaves.