ACADEMIC INN INTERNATIONAL

ISSN NO : 2523-1189

Journal of AGRICULTURAL AND RURAL RESEARCH

open access

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To cite the article: Hammam K. A. and Shoala T. (2020), Influence of spraying Nano-curcumin and Nano-rosemarinic acid on growth, fresh herb yield, chemicals composition and postharvest criteria of French basil (Ocimum basilicum L. var. Grand Vert) plants, *Journal of Agricultural and Rural Research*, 5(1): 1-22.

Link to this article: http://aiipub.com/journals/jarr-200609-010106/

Article QR

Journal QR

INFLUENCE OF SPRAYING NANO-CURCUMIN AND NANO-ROSEMARINIC ACID ON GROWTH, FRESH HERB YIELD, CHEMICALS COMPOSITION AND POSTHARVEST CRITERIA OF FRENCH BASIL (*Ocimum basilicum* L. var. Grand Vert) PLANTS

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ARTICLE INFO

Article Type: Research
Received: 02, June. 2020.
Accepted: 12, June. 2020.
Published: 12, June. 2020.

***Keywords**:*
Nano-curcumin, nano-rosemarinic acid, French basil, Medicinal and Aromatic plants, Pre-harvest, Essential oil, GC analysis, Linalool and Eugenol.

ABSTRACT

The present work was carried out in El-Kanater El- Khairiya, Kalyobia Governorate Farm of Medicinal and Aromatic Plants, Res. Depart. and Postharvest & Handling Res., during two successive seasons 2017&2018.The aim of this work was to investigate the effects of Nano-curcumin (CU-NPs) and Nano-rosemarinic acid (RA- NPs) as foliar treatments, each at 30, 60 and 90 µg on pre -and post-harvest of French basil plants (Ocimum basilicum L var. Grand Vert); traits (growth, storage ability and marketing visual quality and chemical composition. The foliar application Nano-curcumin (CU-NPs) and Nano-rosemarinic acid (RA- NPs) showed positive effects on pre -and post-harvest plant traits. Regarding the effect of these compounds on pre-harvest characters, the obtained results revealed that there were significant increases in height, No. of branches/plant, fresh and dry weights of plants, total chlorophyll %, as well as essential oil % and yield/plant (ml) with increasing the level CU-NPs and RA-NPs. The highest values recorded on growth parameters and essential oil % was obtained with the foliar application of Nano-curcumin and Nano rosemarinic acid, each at 90 µg, in both seasons. The GC-analysis of essential oil indicated that there were thirteen identified components due to the application of both Nano-curcumin and Nano rosemarinic. The contents of linalool and eugenol were the major constituents and reached the highest values (51 and 25% respectively) in plants treated with 90 µg of Nano rosemarinic acid. The response of postharvest traits (storage ability and marketing visual quality and chemical composition) to the application of RA-NPs and CU-NPs, revealed that treating French basil plants with the high level (90 µg) resulted in less fresh weight loss (%),during the three weeks of storage period, than the control plants. The concentration chlorophyll in the cut foliage remained constant during the first week of storage, compared with control, but the storage periods combined with foliar application of RA-NPs and CU-NPs had a significant increase effect on the essential oil percentage of the french basil plant. Moreover, decreased CO2 and increased O2 inside the packages. In addition, application of RA-NPs was more effective and gave the higher values than CU-NPs of French basil plants, except total microorganism CU PNs was the best.

INTRODUCTION

French basil (*Ocimum basilicum* L**.**) is a popular herb species (family Lamiaceae), it is a native of central Asia and northwest India, and it is grown for the fresh highly aromatic herbs (leaves), which are dried and used as a spice or flavoring. The aromatic leaves are utilized either fresh or dried for culinary. **Nema *et al*., (2008)** and **Thakur *et al*., (2014)**. It is a perennial plant adapted to warm growing conditions but is frequently grown as an annual plant. Fresh herbs of French basil plants (*Ocimum basilicum* L var. Grand Vert) have very short storage period after harvest, it is a perishable crop that suffers great losses both in quantity and quality after harvest. Absence of mindfulness and comprehension of postharvest deterioration components bring about genuine postharvest misfortunes, so the pre and postharvest the executives are important to beat this test. Pre and postharvest management such as good cultural and handling practices, temperature and relative humidity management, storage atmosphere management, use of chemicals, appropriate packaging materials and storage structures are used in reducing postharvest losses. The pre-harvest treatments influence the growth, yield and quality of French basil plants. The fresh handling of plants accelerates postharvest senescence due to a high rate of metabolism, and possible microbiological problems and some of the quality indicators can be easily deteriorated after harvest include essential oil %, active components, color degree, and water loss. Product quality is determined by visual appearance (color and absence of decay or insect damage), flavor, moisture content for the fresh market, and volatile oil content and total insoluble ash content for the processing market.

Rosemarinic acid (RA) content in different species of Labiate was 0.0-58.5 mg g-1 of dried herbs; it has interesting properties which has led to a broad range of applications from food preservatives to cosmetics. Different studies have shown that antioxidant activity of RA is more than a vitamin. RA has been reported to have some biological activities such as antiviral properties including antibacterial, antioxidant, anti-carcinogenic and anti-allergic activities. This compound is also efficient against peroxidative damage to biomembranes (**Maryam *et al.*, 2012**). Rosemarinic acid has anti-inflammatory, antiviral and antimicrobial activities. The antioxidant activity of rosemarinic acid is stronger than that of vitamin, which helps to prevent cell damage caused by free radicals **Rossi *et al.*, (2012)**.

Curcuma longa L. is a rhizomatous herbaceous perennial plant of the Zingiberaceae family which contains and accumulates curcumin in rhizomes. This component (curcumin) is primarily used as a treatment for inflammatory conditions and in traditional medicine; it is used as stimulant, anti-bacteria, aspirant, carminative, cordials, astringent, detergent and diuretic. Curcumin contains 2 to 9 % curcuminoids which contains 60 % curcumin and curcumin oxidation yields vanillin. On the other hand, turmeric extract is rich in carbohydrates, (50 % starch), arabinogalactan, potassium salt, essential oils and pigments. It is known for its antioxidant and anti-microbial properties and it has a free radical scavenger activity (namely hydroxyl radical) ,that is responsible to protect DNA from damage and inhibit lipid peroxidation (**Srimal**, **1997** and **Alonso**, **2004**).

Nanotechnology has many applications in all stages of production, processing, storing, packaging and transport of agricultural products. It could be applied in improving important crops as medicinal and aromatic crops, it is considered as one of the possible solutions to problems in agriculture. Now, it plays an important role in increasing production and improving pre- and post-harvest quality of plants. Recently, it has become a growing concern, with the unlimited production of nanoparticles (NPs) and their successful applications in agricultural fields. Nanoparticles are atomic or molecular aggregates with at least one dimension that is approximately between 1 and 100 nm. Nanotechnologies are being developed to increase the absorption of nutrients, which resulted in an increase in the growth rates, quality and quantity of plant production, also, it reduces soil, water and air pollution, which makes agriculture more sustainable (**Sulaima *et al.*, 2017**). Nano natural materials could enhance plant production and secondary metabolites without harming the environment and it has the prospective for the controlling of rapid disease diagnostic of plants (**Shoala, 2018).** Nanotechnology has been defined as relating to materials, systems and processes which operate at a scale of 100 nanometers (nm) or less. Nanotechnology used in all stages of the production of agricultural products such as processing, packaging, transport and storage **Mergany *et al.*, (2019).**

In this regard, **Nazaran *et al.***, (**2009**) showed that treating plants in dry land with Nano-iron increased the chelation of foliar fertilizers, the quantity and quality of wheat compared to control. Also, soybean yield increased significantly in response to exogenous application of nano iron, **Beigi *et al.*,** (**2010). Parandeh *et al.***, (**2011**) revealed that growth parameters in basil plants exposed to high concentrations of Nano Fe (5 Kg.ha-1) were significantly increased compared to untreated plants. On savory plant, it was found that application of Nano iron chelate fertilizer increased chlorophyll content, **Peyvandi *et al.***, **(2011)**. **Sharafzadeh and Alizadeh (2011)** indicated that Nano fertilizers release their nutrients slowly and steadily, it could control and adjust the speed of nutrient release.

Also, **Aysan Ghahremani *et al.*, (2014)** observed that, applying Nano calcium chelate fertilizer simultaneously with nano potassium chelate fertilizer, showed better, biological yield, leaf area, dry matter, chlorophyll content and oil percentage of basil in comparison with control. Moreover, **Zahra Najafivafa *et al.*, (2015)** noticed that, humic acid, Nano Zn chelated fertilizer and the interaction of humic acid and Nano Zn chelated fertilizer had significant in 1 % probability level effects on stem diameter, root length, root dry weight, root fresh weight, phosphorus, number of leaves per plant, chlorophyll content and essential oil content. In another study, **Roosta *et al.*, (2015)** found that all concentrations of foliar spray of mint plants with nano-fertile fertilizer increased fresh and dry weights of shoots and roots , chlorophyll content, soluble sugars as compared to control plants.

Several studies indicated that the application of natural products improved plant growth;in this regard, **El- Masry and Abd El- Rahman (2012)** showed that foliar application of turmeric extract at 0.05 to 0.80 % once, twice, three or four times considerably improved leaf area, total chlorophylls, leaf content of mango. **Huang *et al***., **(2015)** stated that the application of nanotechnology could enhance the fertilization process, plant and crop production through nutrient optimization and decrease the application of pesticides. **Ahmed *et al***., **(2014)** studied the effect of turmeric extract used as a foliar spray on leaf mineral content in mango trees. Found a significant increase in leaf N, P, K content. In addition, **Al-Hadethi and Al-Kubaisy (2015)** found that spraying peach with turmeric extract gave the highest value in leaf N, P, K content. Similarly, **Lukaszewsaka and Kobyliñski, (2009)** reported that SA treatment reduced chlorophyll degradation of detached leaves of *Hippearstrum x chmielii* during storage. **Wei, *et al*., (2011)** reported that the loss of greenness in asparagus spear was delayed by SA application.

Ibrahim (2019) studied the effect of Nano-chitosan on growth, yield components and volatile oil production of chamomile (*Matricaria chamomilla*, L.) plant, he found that treating plants with 5 ml/l Nano chitosan induced significant increases in vegetative growth (plant height, N0. of branches/plant, fresh and dry weights of herb/plant), yield components (dry flower heads yield/ plant and /feddan, yearly), volatile oil production (volatile oil percentage, volatile oil yield/plant and /feddan, yearly) and chemical constituents (K and total carbohydrates percentages in flower heads and total chlorophyll a + b content in leaves), as compared with control plants which untreated.

Thus, the objective of this work was to investigate the preharvest Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) foliar treatments on growth of French basil plants (*Ocimum basilicum* L var. Grand Vert) aiming to increase the fresh weight and percentage of the essential oil, as well as to prolong the survival of the plant in good condition as long as possible after harvest and during storage and marketing.

MATERIALS AND METHODS

The experiment was carried out to study the influence of spraying Nano-curcumin (CU NPs) and Nano rosemarinic acid (RA NPs) on growth, fresh herb yield and quality pre and post-harvest of French basil plants (*Ocimum basilicum* L var. Grand Vert), during the two successive seasons of 2017 and 2018, in the Farm of Med & Aromatic Plants Res. Depart., El-Kanater El- Khairiya, Kalyobia Governorate and Hort. Res., Institute, Dokki, Giza.

Plant materials

French basil seedlings (*Ocimum basilicum* L var. Grand Vert), were obtained from the Medicinal and Aromatic Plants Depart., El-Kanater El- Khairiya, Kalyobia Governorate, Horticulture Research Institute.

This study was divided into parts as follows:

1- The first part was done to investigate the effect of Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) as foliar treatments on growth of French basil plants (*Ocimum basilicum* L var. Grand Vert) and percentage of the essential oil.

2- The second part was done to investigate the effect of Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) on postharvest traits (storage ability and marketing visual quality and chemical composition of the plants.

I. Procedure of the first part:

Soil preparation and planting

French basil seedlings were planted on 23th and 22nd March in the first and second seasons, respectively, at a spacing of 60 x 25 cm, on one side of the row. The experimental plots were 3.0 x 2.50

meters, with 3 rows at distance of 60 cm between them. Phosphorus fertilizer was mixed with soil before transplanting (200 kg/fed as calcium superphosphate), Potassium sulphate (as a source of K) was applied at 75 kg/ fed. Nitrogen (N) was applied at a rate of 300 kg /fed using ammonium nitrate. Half dose of N and K were applied 21 days after planting and the second one was applied one month later. Physical and chemical analysis of the experimental soil was: Texture Class: clay, organic matter 2.17 %, E.C. (ds/m) 0.26 and pH = 7.5.

Nano rosemarinic acid and Nano curcumin application

After 21 days from transplanting, the seedlings were treated with Nano curcumin (NC) and Nano rosemarinic acid (NR) at the rate of 30, 60 and 90 µg. The second one (spray) was applied after 15 days. Nano rosemarinic acid and curcumin materials were prepared as aqueous solutions supplemented with Tween 20 at 0.05 ml/l, while control was sprayed with tap water.

Data recorded in the first part were:

Plants were harvested by cutting the herb at 10 cm above soil surface without bruising or injuring the leaves and stems on 23th and 24th May in the two seasons, respectively, the following observations were recorded:

- **a- Growth parameters**: Plant height (cm), number of branches per plant, fresh and dry weights of the plant (g), leaf area (cm^2). Leaf area was measured using CI-203 Handheld Laser Leaf Area Meter (CID, Bioscience) in Central Lab. for Agric. Climate (CLAC).
- **b- Total chlorophyll content** (%): total chlorophyll was determined using METER MINOLTA SPAD (502), according to **A.O.A.C. (1990).**
- **c- Essential oil percentage and yield/plant:**

To determine the essential oil percentage; samples of fresh leaves (100g) were subjected to the hydro-distillation using a Clevenger apparatus according to the methods described by **British Pharmacopeia (2002).**

- **d- Chemical analysis of the essential oil (GC) :**

The analysis conditions were as follows**:** The volatile oil was analyzed in the Lab. of Med & Aroma Plants, Res. Depart. Hort. Res. Institute (ARC) using Ds Chrom 6200 **Gas** Chromatograph apparatus.It was fitted with capillary column BPX-5, 5 phenyl (equiv.) polysillphenylene-siloxane 30 x 0.25 mm ID x 0.25µ film. Temperature program ramp increase with a rate of 10 oC / min from 70 o to 200oC. Flow rates of gases were nitrogen at 1 ml/min, hydrogen at 30 ml/ min and 330 ml/min for air detector and injector temperatures were 300 ^{o}C and 250 ^{o}C respectively. The obtained chromatogram and report at GC analysis for each sample were analyzed to calculate the percentage of main components of the volatile oil.

The experiment consisted of 7 treatments, with three levels from Nano curcumin and Nano rosemarinic acid (30, 60 and 90 µg). The experiment was arranged in a randomized complete block design with three replications.

The Nano curcumin (CU NPs) and Nano rosemarinic acid (RA NPs) were:

1- 0 (control) was sprayed with tap water.

2- 30 µg Nano curcumin (CU NPs).

3- 60 µg Nano curcumin (CU NPs).
4- 90 µg Nano curcumin (CU NPs).
5- 30 µg Nano rosemarinic acid (RA NPs).
6- 60 µg Nano rosemarinic acid (RA NPs).
7- 90 µg Nano rosemarinic acid (RA NPs).

Synthesis of Nano curcumin (CU-NPs).

Curcumin was purchased from Sigma-Aldrich Company (CAS Number: 458-37-7), stock of curcumin solution (5 mg/ml) was prepared by dissolving curcumin powder in dichloromethane (20 ml). One ml of stock solution was added to boiling water (50 ml) in drop-wise manner under ultra-sonication condition (XUBA3Analogue Ultrasonic Bath, Grant Company) with an ultrasonic power and frequency of 50 kHz. The solution was sonicated for about 30 min. After sonication, the mixture was stirred at 800 rpm for 20 min till the orange colored precipitate was obtained. Thereafter, supernatant was discarded and the pellet obtained was used for further study.

Synthesis of Nano rosemarinic acid (RA NPs).

Rosmarinic acid was purchased from Sigma-Adrich Company (CAS Number: 20283-92-5), 10 mg of rosemarinic acid was dissolved in 10 ml absolute ethanol and sonicated (XUBA3Analogue Ultrasonic Bath, Grant Company) with an ultrasonic power and frequency of 50 kHz for an hour at room temperature (25°C).

Characterization of NPs

Dynamic light scattering (DLS)

Measurement of Cu NPs and RA NPs distribution and size was performed by a dynamic light scattering method using Zeta seizer Nano ZS (Malvern Instruments, UK) at room temperature. Prior to measurement, 30µl of the nanoparticle was diluted with 3ml of water at 25°C. Particle size data were expressed as the mean of the Z-average of 3 independent batches of the nanoparticles.

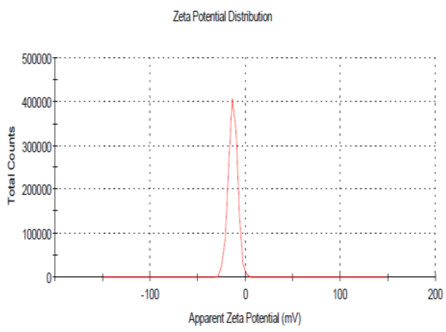

Figure 1. Zeta potential for curcumin (CU NPs) nanoparticles

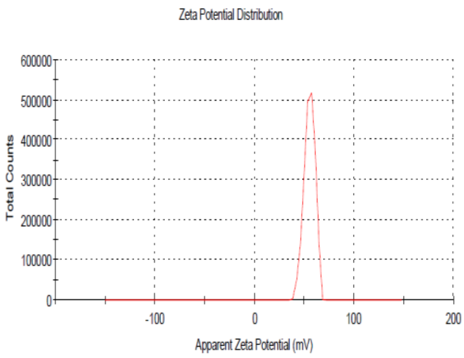

Figure 2. Zeta potential for of rosemarinic acid (RA NPs) nanoparticles

II. Procedure of the second part:

In this part we studied the influence of spraying Nano-curcumin and Nano-rosemarinic acid on storage period, weight loss %, total chlorophyll %, O_2 and CO_2 consumption essential oil % in addition prolonging the shelf life plants. After harvesting the fresh herb , the following treatments, were done at the Postharvest & Handling Department in Horticulture Research Institute, ARC, Giza: storage of the herb at 10 C with different periods: 1, 2 and 3 weeks., using one commercially available polymeric film bags as packaging materials. The investigated polymer material was polyethylene (15x20 cm) of 40 µm thickness. French basil plants were packaged; each package contained 100 g as one replicate. The different packages were divided into three groups; placed inside refrigerator and stored at temperatures 10 ^{o}C at 95 % RH for three weeks. Samples were taken at random from 3 replicates of each treatment and examined immediately after harvest as well every the day's intervals three times for the following properties:

1-**Weight loss percentage:**

The herbs were weighted every week and the weight loss during storage was calculated by comparing with the weight at the initial day of storage. The data was present as the percentage of weight loss (weight loss %).

Weight loss percentage was estimated according to the following equation:

As: W**eight lost** % = initial weight of herb – the weight of herb at sampling date x100 / The initial weight of herb

2-**Total chlorophyll content (%):**

It was estimated during the different storage periods (1, 2 and 3 weeks), using METER MINOLTA SPAD (502), according to **A.O.A.C. (1990)**.

3- **Gas composition inside the packages**:

The concentrations of O_2 and CO_2 inside the packages were monitored using Dual Trak model 902 D gas analyzer, by inserting the test probe through a rubber seal attached to the outside of the package.

4-**Essential oil percentage (%):**

It was estimated by weighting 100 g of fresh leaves, and then it was subjected to the hydro-distillation using Clevenger apparatus according to the methods described by **British Pharmacopeia (2002).**

5-**Total microbial count**

Total microbial count bacteria count (-x108 CFU/g) and total fungi count (-x105)} was determined in Fac. of biotechnology Laboratory, Misr University for Science & Technology October 6 City according to **Marshall (1992).**

The layout of the experiment and statistical analysis

This factorial experiment consisted of 7 treatments of Nano curcumin (CU-NPs) and Nano rosemarinic acid (RA-NPs) with three periods of storage. The experiment was arranged in a randomized complete block design with three replications, as described by **Gomez and Gomez (1984)** using the L.S.D. test at 0.05.

RESULTS AND DISCUSSIONS

I-Effect of spraying Nano curcumin and Nano rosemarinic acid on growth characters and chemical composition in pre-harvest:

1- Plant height and No. of branches/plant

Data presented in Table (1) showed that, in general, the different levels (30, 60 and 90 µg) of Nano curcumin and Nano rosemarinic acid (CU-NPs and RA-NP) positively affected growth characters of French basil plants in terms of plant height and No. of branches/ plants, in both seasons. **Allah Wasaya *et al.*, (2020)** on mungbean (*Vigna radiata* L.) reported that, nanoparticles increase crop nutrient utilization. It also improves plant growth and yield by increasing the resistance of plants as well as uptake of nutrients by deeper root system.

Furthermore, plant height significantly increased to 63.00 in the 1st season and 65.56 cm in the 2nd one, in plants treated with RA-NPs at the high level (90 µg) against 59.00 and 58.78 cm, respectively for plants treated with CU NPs, while the corresponding height of the control plants were 52.00 and 53.50cm. Also, treating French basil plants with 90 µg RA-NPs recorded the highest No. of branches/plant (13.65, 1st season and 14.45, 2nd season) compared to (11.75, 1st season and 12.09 2nd season) in plants treated with 90 µg CU-NP$_S$ and (8.45, 1st season-7.11, 2nd season) in the control plants. This result could be due to the important role of turmeric extracts that contain carbohydrates, (50 % starch), arabinogalactan, potassium salt, essential oils and pigments, and which plays an important role in plant growth. **(Srimal, 1997 and Alonso, 2004).** In this regard, **Huang *et al.*, (2015)** mentioned that the uses of nanomaterial specifically for the agricultural purposes are required for improving the fertilization process, increasing yields through nutrient optimization and minimizing the requirements of plant protection products.

Table 1. Influence of spraying Nano- curcumin (CU-NPs) and Nano-rosemarinic acid (RA-NPs) on plant height, number of branches/plant and leaf area (cm^2) of french basil during 2017 and 2018, seasons.

Treatments	Plant height (cm)		No. of branches/plant		Leaf area (cm^2)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	52.00	53.50	8.45	7.11	21.22	21.61
30 µg Nano curcumin	52.37	53.52	8.38	8.02	22.82	22.23
60 µg Nano curcumin	54.66	56.77	9.68	10.45	25.28	24.62
90 µg Nano curcumin	59.00	58.78	11.75	12.09	28.23	27.73
30 µg Nano rosemarinic	54.33	54.50	9.66	9.23	25.50	24.63
60 µg Nano rosemarinic	56.00	58.54	11.35	12.11	28.11	27.72
90 µg Nano rosemarinic	63.00	65.56	13.65	14.45	29.63	30.18
LSD at: 0.05	2.50	3.17	1.70	2.38	2.13	2.24

2- Leaf area:

Also, data in Table (1) showed leaf area in treated basil plants with 90 µg of RA NPs showed a significant increase (29.63 cm^2, in 1st season and 30.18 cm^2, in 2nd one) compared to (21.22 cm^2,1st season-21.61 2nd season) in untreated plants, while leaf area recorded (28.11 cm^2, 1st season-27.72 cm^2 2nd season) were obtained with the treatment of RA NPs at 60 µg. Application of RA NPs on leaf area, it was clear that, application of 30, 60 and 90 µg increased leaf area (cm^2) of French basil by 20.17, 32.44 and 39.61%, respectively over the untreated plants during the first season and a similar trend had been obtained, in the second one. On the other hand, the application of CU-NPs at all levels increased the leaf area of French basil over the untreated plants, in both seasons. The higher content of turmeric (curcumin) extracts from antioxidants especially phenolic compounds, nutrients and plant pigments has an important role in stimulating cell division , which could explain our present results **(Pons, 2003).** These results are in harmony with that obtained by **El- Wasfy *et al*., (2013).**

3- Fresh and dry weight/ plant.

French basil plants treated with 90 µg of RA NPs showed a significant increase in the fresh weight over the control plants, giving 231.00g/plant in the 1st season and 226.01g/plant in the second one, against 151.31and 146.21g/plant, respectively, for control plants. However, treating plants with 90 µg of CU NPs increased significantly fresh weight to 207.44 g/plant in the 1st season and 210.00 g/plant in the 2nd one (Table 2).

On the other side, the dry weight of plants increased significantly with the application of 90 µg RA NPs (34.21g/plant in the 1st season -33.42g/plant in the 2nd season), as well as the application of 90µg CU NPs (29.47g/plant in the 1st season -30.77g/plant in the 2nd season) respectively, compared to (21.60g/plant in the 1st season -22.00g/plant in the 2nd season) in the untreated plants. Curcumin has a free radical scavenger activity namely hydroxyl radical that is responsible to protect DNA from damage and inhibit lipid peroxidation **(Alonso, 2004).**

Similarly**, Ibrahim (2019)** studied the effect of Nano-chitosan on growth of chamomile (*Matricaria chamomilla*, L.) plant, he found that treating chamomile plants with 5 ml/l Nano chitosan induced significant increases in vegetative growth (plant height, No. of branches/plant, fresh and dry weights of herb/plant), yield components (dry flower heads yield/plant and /feddan, yearly).

Table 2. Influence of spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) on fresh and dry weight/plant and essential oil % of french basil during 2017 and 2018, seasons.

Treatments	Fresh weight/plant(g)		Dry weight/plant (g)		Total chlorophyll %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	151.31	146.21	21.60	22.00	35.00	36.65
30 µg Nano curcumin	176.21	173.25	24.45	23.25	35.00	34.55
60 µg Nano curcumin	191.11	188.35	26.52	26.45	36.10	36.13
90 µg Nano curcumin	207.44	210.00	29.47	30.77	38.05	37.20
30 µg Nano rosemarinic	180.55	182.44	25.64	24.27	35.00	36.45
60 µg Nano rosemarinic	195.25	192.22	28.11	27.54	37.22	38.54
90 µg Nano rosemarinic	231.00	226.01	34.21	33.42	40.56	41.77
LSD at 0.05	**8.22**	**6.25**	**1.91**	**2.39**	**3.92**	**3.98**

4-Total chlorophyll

Color is the most evident parameter by which consumers evaluate the quality of French basil fresh herb. The percentage of total chlorophyll, in plants treated with 90 µg RA NPs, increased significantly to 40.56% in the 1st season and 41.77% in the 2nd one, compared to 35.00 and 36.65%, respectively, for the control. However, the percentage of total chlorophyll, in the treated French basil plants with 60 µg RA NPs and 60 µg CU-NPs were nearly the same (Table 2). On chamomile plant, **Ibrahim (2019),** found that treating chamomile plants with 5 ml/l Nano-chitosan induced significant increases in the total chlorophyll a + b content in leaves) as compared with control plants which untreated.

5- Essential oil percentage

From data in Table (3), it can be concluded that application of different levels of Nano-curcumin and Nano- rosemarinic acid had a significant effect on increasing the content of essential oil in leaves of French basil plants (*Ocimum basilicum* L var. Grand Vert) especially at 60 and 90 µg.

The percentage of total essential oil in French basil, augmented significantly to (0.50% in the 1st season 0.49% in the 2nd season) in response to the application of 90 µg RA NPs, compared to (0.34% in the 1st season 0.33% in the 2nd season) in the control. However, the percentage of total essential oil, in the treated French basil plants with 90 µg CU NPs were (0.41% in the 1st season 0.40% in the 2nd season).

6- Essential oil yield/ plant

Regarding the effect of Nano-curcumin CU NPs and Nano-rosemarinic acid RA NPs on essential oil yield/plant (ml), the data in indicated that application of different levels of CU NPs and RA NPs were steady significantly increased the essential oil yield/plant (Table 3).

French basil treated with 90 µg of RA NPs, showed significant increases in the yield of essential oil (1.16 ml/plant in the 1st season- 1.11 ml/plant in the 2nd season), compared to the untreated plants (0.51and 0.48 ml/plant in both seasons). On the other side, the essential oil yield in plants treated with 90 µg of CU NPs reached to 0.85ml/plant in the 1st season- and to 0.80ml/plant in the 2nd one. **Ibrahim (2019)**, on chamomile plant found that treating plants with 5 ml/l Nano chitosan significantly increased volatile oil production (volatile oil percentage, volatile oil yield/plant and /feddan, yearly), as compared with control plants which untreated.

Table 3. Influence of Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) on essential oil % and essential oil yield/plant of french basil during 2017 and 2018, seasons.

Treatments	Essential oil %		Essential oil yield/plant (ml)	
	1st season	2nd season	1st season	2nd season
Control	0.34	0.33	0.51	0.48
30 µg Nano curcumin	0.35	0.36	0.62	0.62
60 µg Nano curcumin	0.38	0.37	0.73	0.70
90 µg Nano curcumin	0.41	0.40	0.85	0.80
30 µg Nano rosemarinic	0.35	0.35	0.63	0.64
60 µg Nano rosemarinic	0.43	0.43	0.84	0.83
90 µg Nano rosemarinic	0.50	0.49	1.16	1.11
LSD at: 0.05	**0.03**	**0.03**	**0.05**	**0.06**

7-Essential oil composition

The results obtained from the essential oil compositional analysis of French basil (*Ocimum basilicum* L var. Grand Vert) plants subjected to Nano curcumin and Nano rosemarinic acid foliar applications are presented in Table (4). In total, thirteen components were identified in the essential oil of treated plants. Linalool and eugenol were the major constituents of essential oil in plants treated with the different treatments of Nano curcumin and Nano rosemarinic acid, as detected by GC-analysis. The highest values of linalool (51.00 %) and eugenol (25.00 %) were obtained from plants treated with 90 µg Nano rosemarinic acid. It seems that the foliar application of these compounds had positive effects on the biosynthesis and accumulation of these high–valued compounds. The least value of linalool (43.72 %) was recorded in the essential oil extracted from untreated plants, while the least value from eugenol was obtained from plants treated with 30 µg Nano-curcumin. Treating French basil plants with 90 µg and 9o µg of RA NPs significantly increased the linalool percentage to 51.00 % and 49.58%, respectively, compared to 43.72% in the untreated plants. However, the percentage of linalool in treated French basil with 90 µg and 30 µg of Cu NPs was 47.41% and 45.00% respectively. Additionally, the percentage of eugenol in treated plants with 90 µg and 60 µg of RA NPs were 25.00% and 23.68%, respectively compared to 20.00% in the untreated plants.

Table 4. Influence of spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) on essential oil composition of french basil during, 2018 season.

Compounds %	Treatments						
	Nano rosemarinic acid				Nano curcumin		
	Cont.	30 µg	60 µg	90 µg	30 µg	30 µg	90 µg
α-Pinene	0.43	6.40	4.29	0.94	0.30	4.76	0.62
Myrcene	0.50	3.37	1.97	0.62	0.37	3.87	6.32
β-Pinene	5.66	--	3.10	6.74	0.22	2.83	2.96
Linalool	43.72	49.58	45.00	51.00	45.00	44.99	47.41
Canphor	0.58	5.33	2.48	3.16	1.55	1.01	6.37
δ -Terpineole	0.35	1.88	1.58	1.54	1.32	1.09	2.14
Terpinene	0.42	1.03	1.21	1.31	2.32	2.09	1.95
α-Terpineole	5.29	4.07	1.81	1.26	2.30	2.83	0.96
Methyle chavicol	0.54	2.15	0.98	3.07	5.20	7.07	4.68
Fenchyl acetate	0.53	3.58	5.19	1.60	2.10	2.91	2.36
Geraniol	1.79	0.82	2.05	2.08	1.10	2.31	3.20
Eugenol	20.00	19.59	23.68	25.00	19.21	19.67	20.05
β-Caryophylene	0.49	1.91	0.90	--	0.17	1.38	--
Total	80.30	99.71	94.24	98.32	81.16	96.81	99.02

II- Effect of spraying Nano-curcumin CU NPs and Nano-rosemarinic acid RA NPs on post-harvest criteria:

The objective of this part was to investigate the effect of Nano-curcumin (CU-NPs) and Nano-rosemarinic acid (RA-NPs) foliar treatments on survival of the plant in good quality as long as possible after harvest and during storage and marketing.

1- Fresh weight loss %

In this work, the presented data in Table (5) data indicated that, fresh weight loss progressively increased with prolonging the storage period from 1week to 2 and 3 weeks. The highest fresh weight loss (5.46 and 5.59 %) was obtained from plants stored for 3 weeks in the first and second seasons, respectively.

The data also showed, in general, that weight loss increased significantly with prolonging storage period. French basil treated with 60 and 90 µg of CU NPs or RA NPs last in good quality for long storage period more than the control, for fresh consumption or marketing after harvesting and good marketing quality during different storage periods (1, 2 or 3 weeks).

Table 5. Influence of spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) on fresh weight loss (%) of French basil plants during 3 weeks storage period in 2017 and 2018.

Treatments	Fresh weight loss %							
	Storage period							
	First season 2017				Second season 2018			
	1 Week	2Weeks	3Weeks	Mean-A	1 Week	2Weeks	3Weeks	Mean-A
Control	6.20	9.11	12.14	9.15	6.98	10.15	13.08	10.07
30 µg Nano curcumin	3.50	4.75	5.56	4.60	3.30	4.60	5.61	4.50
60 µg Nano curcumin	2.75	3.80	5.00	3.85	2.69	3.74	5.01	3.81
90 µg Nano curcumin	1.32	3.14	3.60	2.69	1.44	3.29	3.57	2.77
30 µg Nano rosemarinic	3.15	4.65	5.91	4.57	3.28	4.28	5.31	4.29
60 µg Nano rosemarinic	2.31	3.55	4.00	3.29	2.60	3.60	4.55	3.58
90 µg Nano rosemarinic	1.03	2.03	2.03	1.70	1.20	2.20	2.00	1.80
Mean B	2.89	4.43	5.46	4.26	3.07	4.55	5.59	4.40
LSD at 0.05	**Spray:1.25, St.period:0.82, StxSp:2.15**				**Spray:1.44, St.period:0.91, StxSp:2.17**			

Fresh weight loss decreased (during the three weeks storage) in treated French basil plants compared to control. Treated French basil plants sprayed with 90 µg of RA NPs and CU NPs in the first season showed that the percentage of fresh weight loss was significantly decreased to 1.70 %, 3.60 % respectively compared to 12.14% after three weeks of storage. However, in the second season, treating French basil plants with 90 µg of RA NPs and CU NPs showed that the percentage of fresh weight loss was significantly decreased to 2.00%, 3.57% respectively, as compared to 13.08% for the control, after three weeks storing time. This means that fresh herb of French basil harvested from plants treated with CU NPs or RA NPs was firmer and the rate of decay was slow, it can be attributed this result to the low rate of respiration, transpiration and other senescence factors related to metabolic process during storage. Also, we noted that the interaction between different levels of Nano-applications and storage periods was significant. The lowest percentage of fresh weight loss (1.03 and 1.20 %) from plants treated with 90 µg RA NPs and stored for a week, in both seasons, respectively, followed by (1.32 and 1.44 %) for plants received 90 µg CU-NPs and stored for a week.

2-Total chlorophyll content %

The Influence of spraying Nano-curcumin and Nano-rosemarinic acid on total chlorophyll content, as an indicator to fresh herb color and quality (Table 6) indicated that the chlorophyll concentration remained constant in the first week of storage compared with control, then it decreased during the second and third weeks, probably due to decay, in the two seasons. The percentage of total chlorophyll during the first season in treated French basil plants with 90 µg of RA-NPs and CU-NPs showed a significant increase (40.38% and 37.63%, respectively), compared to 26.17%, after 3 weeks of storing time. However, during the second season the percentage of total chlorophyll in plants treated with 90 µg of RA NPs and CU NPs increased significantly to 39.25% and 36.21%, respectively, compared to 27.10% in the untreated plants in the third week of storage (Table 6). The decrease in the chlorophyll content may be due to the increased rate of chlorophyll degradation by chlorophyllase enzyme. Our results agreed with **(Sakaldas and Kays 2010)** and **(Masoud, 2011).**

Also**,** Data in Table (6) showed that in the two seasons the total chlorophyll content decreased with the extended storage period as a result of the respiration. As for, the effect of different levels of Nano-materials application, the obtained data indicated that, the highest value of total chlorophyll content in fresh herb of French basil was obtained with the treatments of RA NPs and CU NPs , each at 60 and 90 µg from plants stored at 1 week. The degradation of the chlorophyll % with the increase of storage time was obvious for the untreated plants in comparison with any treated plants. In addition, the interaction between storage period and different levels of Nano-materials application, as shown in Table (6) showed that French basil plant treated with NRA at the level 90 µg and stored for 1 or 2 weeks resulted the highest values of total chlorophyll %, in both seasons. After 3 weeks of storage, the treatment of CU NPs at 30 µg gave the lowest values of total chlorophyll %.

Table 6. Influence of spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) on total chlorophyll % of French basil during 3 weeks storage period in 2017 and 2018.

Treatments	Total chlorophyll %									
	Storage period									
	First season 2017					Second season 2018				
	0	1 W	2 W	3 W	Mean A	0	1 W	2 W	3 W	Mean A
Control	35.00	32.11	29.12	26.17	30.60	36.65	33.02	30.09	27.10	31.72
30 µg Nano curcumin	35.00	33.75	32.45	31.00	33.05	34.55	33.00	31.50	30.77	32.46
60 µg Nano curcumin	36.10	36.00	35.00	34.65	35.44	36.13	36.00	35.00	34.03	35.29
90 µg Nano curcumin	38.05	38.05	37.40	37.00	37.63	37.20	37.20	37.94	36.21	37.14
30 µg Nano rosemarinic	35.00	34.02	33.00	32.20	33.56	36.45	35.55	33.49	32.50	34.50
60 µg Nano rosemarinic	37.22	37.22	36.35	35.44	36.56	38.54	38.30	38.30	37.00	38.04
90 µg Nano rosemarinic	40.50	40.50	40.50	40.00	40.38	41.77	41.77	41.00	39.25	40.95
Mean B	36.70	35.95	34.83	33.78	35.31	37.33	36.41	35.33	33.84	35.73
LSD at 0.05	0 Time: 3.92 Spray:1.47 St.period:0.96 StxSp:2.35					0 Time: 3.98 Spray:1.52 St.period:0.88 StxSp:2.29				

3-Essential oil %

The content of essential oil in the postharvest stage was influenced by the different storage periods in combination with CU- NPs and RA-NPs. Data in Table (7) showed that the storage periods had a significant effect on the essential oil percentage of the French basil plant. In general, prolonging the storage period decreased steadily the essential oil %, i.e. the highest percent (0.39 and 0.38 % in the two seasons, respectively) was determined with the shortest storage period (1 week), followed by herb stored for 2 weeks, while the lowest percentages (0.36 and 0.35 %) were determined for the longest storage (3 weeks),in both seasons, respectively. Concerning the effect of different Nano-materials sprays, the data in the two seasons revealed that there was a significant difference between the effect of CU-NPs and RA-NPs on the content of essential oil storage. French basil plant treated with RA NPs at 90 µg gave the highest values from essential oil % (0.49 and 0.48 %) in the two seasons, respectively, While the lowest ones (0.29 and 0.28 %) were determined from untreated plants (Control). There was an interesting relation between the effect of storage period and different Nano-materials sprays, as the most effective treatment in promoting essential oil % was the combined treatment of Nano rosemarinic acid and one-week storage. After 3 weeks of storage, the untreated plants gave the least values of essential oil percent (0.25 and 0.24 % in the first and second seasons; respectively).

Table 7. Influence of spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) on essential oil % of French basil plants during 3 weeks storage period in 2017 and 2018.

Treatments	Essential oil %									
	Storage period									
	First season 2017					Second season 2018				
	0	1 W	2 W	3 W	Mean	0	1 W	2 W	3 W	Mean
Control	0.34	0.30	0.28	0.25	0.29	0.33	0.29	0.26	0.24	0.28
30 µg Nano curcumin	0.35	0.35	0.34	0.32	0.34	0.36	0.36	0.34	0.32	0.35
60 µg Nano curcumin	0.38	0.38	0.37	0.36	0.37	0.37	0.37	0.36	0.34	0.36
90 µg Nano curcumin	0.41	0.41	0.41	0.40	0.41	0.40	0.40	0.40	0.39	0.40
30 µg Nano rosemarinic	0.35	0.35	0.34	0.31	0.34	0.35	0.35	0.34	0.32	0.34
60 µg Nano rosemarinic	0.43	0.43	0.43	0.42	0.43	0.43	0.43	0.41	0.39	0.42
90 µg Nano rosemarinic	0.50	0.50	0.47	0.48	0.49	0.49	0.49	0.48	0.46	0.48
Mean	**0.39**	**0.39**	**0.38**	**0.36**	**0.38**	**0.39**	**0.38**	**0.37**	**0.35**	**0.37**
LSD at 0.05	**0Time: 0.03 Spray: 0.04 St.period:0.03 StxSp:0.08**					**0Time: 0.03 Spray: 0.05 St.period:0.04 StxSp:0.07**				

4-Gas concentration inside the packages:

-Respiration rate

Gas composition is an indication of a product's respiration rate which is directly proportional to metabolic rate **Kou, *et al.*, (2014).** It was clear a gradual change in O_2 and CO_2 level in both seasons during the storage period, data in Tables (8&9) showed that oxygen (O_2) levels in the packages initially decreased slowly gradually from 1 to 3 weeks (2.68, 2.40 and 2.25 %) and (2.66, 2.42 and 2.26 %) in both seasons, respectively. In contrast, carbon dioxide (CO_2) concentration initially increased rapidly, followed by a slight decline (8.44, 9.43 and 10.52 %) in the two seasons, respectively. These results were harmony with Loaiza and Cantwell, (1997) that attributed that to the consumption of O2 and production of CO2 from parsley plant during its respiration process. **Hammam (2016)** reported that, a significant decrease in O_2 % and increase of CO_2 % during the storage period as a result of its respiration. Another point of view, the data recorded in Table (8&9) also, revealed that the effect of different levels of spray application of Nano curcumin and Nano rosemarinic acid on gas composition. Samples in the packages with RA NPs at 90 µg gave the highest values from O_2 % (4.85 and 4.77 %) in the first and second seasons, respectively and in contrast resulted the lowest values from CO_2 % (6.93 and 7.05 %), followed by (3.38 and 3.32 %) and (7.44 and 7.48 %) were obtained from plants treated with CU NPs at 90 µg from O_2 and CO_2 in both seasons, respectively.

Table 8. Oxygen percentage (O_2) in the fresh herb of French basil fresh herb as affected by spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) and different storage period during 3 weeks storage period in 2017 and 2018.

Treatments	Oxygen %							
	Storage period							
	First season 2017				Second season 2018			
	1 Week	2 Weeks	3 Weeks	Mean	1 Week	2 Weeks	3 Weeks	Mean
Control	0.55	0.46	0.37	0.46	0.57	0.47	0.36	0.47
30 µg Nano curcumin	1.50	1.30	1.10	1.30	1.49	1.31	1.15	1.32
60 µg Nano curcumin	2.30	2.00	1.81	2.04	2.31	2.10	1.90	2.10
90 µg Nano curcumin	3.78	3.30	3.05	3.38	3.69	3.28	3.00	3.32
30 µg Nano rosemarinic	2.36	1.92	1.71	2.00	2.35	1.90	1.73	1.99
60 µg Nano rosemarinic	3.27	3.00	3.00	3.09	3.30	3.05	3.05	3.13
90 µg Nano rosemarinic	5.02	4.82	4.70	4.85	4.90	4.80	4.61	4.77
Mean	2.68	2.40	2.25	2.44	2.66	2.42	2.26	2.44
LSD at 0.05	**Spray:1.18, St.period:0.77, StxSp:2.15**				**Spray:1.25, St.period:0.79, StxSp:1.95**			

Table 9. Carbon dioxide concentrations in the fresh herb of French basil as affected by spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) and different storage period during 3 weeks storage period in 2017 and 2018.

Treatments	**Carbon dioxide**							
	Storage period							
	First season 2017				**Second season 2018**			
	1 Week	2 Weeks	3 Weeks	Mean	1 Week	2 Weeks	3 Weeks	Mean
Control	10.21	13.03	17.00	13.41	10.00	12.95	16.78	13.24
30 µg Nano curcumin	9.50	10.60	11.00	10.37	9.83	10.72	10.98	10.51
60 µg Nano curcumin	8.70	8.90	9.25	8.95	8.80	8.99	9.97	9.25
90 µg Nano curcumin	7.00	7.40	7.91	7.44	6.95	7.50	8.00	7.48
30 µg Nano rosemarinic	9.15	10.50	12.30	10.65	9.41	10.50	12.27	10.73
60 µg Nano rosemarinic	8.00	8.56	8.90	8.49	7.96	8.47	8.93	8.45
90 µg Nano rosemarinic	6.50	7.00	7.30	6.93	6.54	7.15	7.47	7.05
Mean	8.44	9.43	10.52	9.46	8.50	9.47	10.63	9.53
LSD at 0.05	**Spray:1.32, St.period:0.86, StxSp:2.14**				**Spray:1.29, St.period:0.82, StxSp:2.11**			

Also, the data recorded in Tables (8&9) showed significant effects for the interaction between the application of CU NPs and RA NPs levels and different storage period compared with control. In both seasons, the highest values in terms of the O_2 and lowest values in terms of CO_2, (5.02 and 4.90 %) and (6.50 and 6.54 5) were obtained with plants treated with NRA at 90 µg and stored with 1 week in the first and second seasons, respectively). In the respiratory process, microorganisms consume O_2 and release CO_2 in the atmosphere; along the storing period, there is an accumulation of CO_2 in the atmosphere **Franceli *et al*., (2005).**

5-Total count of microorganism:

The result indicated that the growth of microorganism of French basil fresh herb was inhibited by the application of different levels of Nano curcumin CU NPs and Nano rosemarinic acid RA NPs compared with control and CU NPs gave the best results from RA NPs. Table 10 and Figures (3&4). Moreover, the total count microorganism contents of the leaves of French basil significantly depended on the type of application, its level and storage period (1, 2 or 3 weeks). The best results (12.5 and 21.75) were obtained from plants treated with CU NPs at 90 µg in the first and second seasons, respectively, followed by (172.50 and 197.25) were obtained from plants supplied with RA NPs at 90 µg. The finding supports the existing knowledge on that increasing storage period can stimulate microbial proliferation in minimally processed fresh produces **Jacxsens *et al*., (2002).**

Regarding the effect of combined with storage period and application of Nano curcumin and rosemarinic acid, data recorded in Table (10) observed that the best combined between storage period and of the compound were obtained from plants supplied with CU NPs at 90 µg and stored with 1 or 2 weeks in the two seasons. Furthermore, the greatest total counts of microorganisms (870 and 900) were obtained from plants stored 3 weeks and untreated plants.

Table 10. Total count of microorganisms in herb of french basil as affected by spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) and different storage periods, in 2017 and 2018, seasons.

Treatments	Total count microorganism									
	Storage period									
	First season 2017					Second season 2018				
	0	1Week	2W	3W	M	0	1W	2W	3W	M
Control	290.00	350.00	590.00	870.00	525.00	300.00	350.00	600.00	900.00	537.50
30 µg Nano curcumin	128.00	128.00	128.00	13.00	129.75	140.00	140.00	140.00	178.00	149.50
60 µg Nano curcumin	69.00	69.00	69.00	69.00	69.00	75.00	75.00	75.00	95.00	80.00
90 µg Nano curcumin	10.00	10.00	10.00	20.00	12.50	17.00	17.00	17.00	36.00	21.75
30 µg Nano rosemarinic	227.00	227.00	265.00	280.00	249.75	240.00	240.00	250.00	280	252.50
60 µg Nano rosemarinic	200.00	200.00	220.00	230.00	212.50	220.00	220.00	230.00	260.00	232.50
90 µg Nano rosemarinic	170.00	170.00	170.00	180.00	172.50	180.00	180.00	196.00	233.00	197.25
Mean	156.29	164.86	207.43	254.86	195.86	167.43	174.57	215.43	283.14	210.14
LSD at 0.05	**Spray: 193.83, St. period: 126.89 St x Sp: 335.73**					**Spray: 194.02, St. period: 129.11 St x Sp: 338.74**				

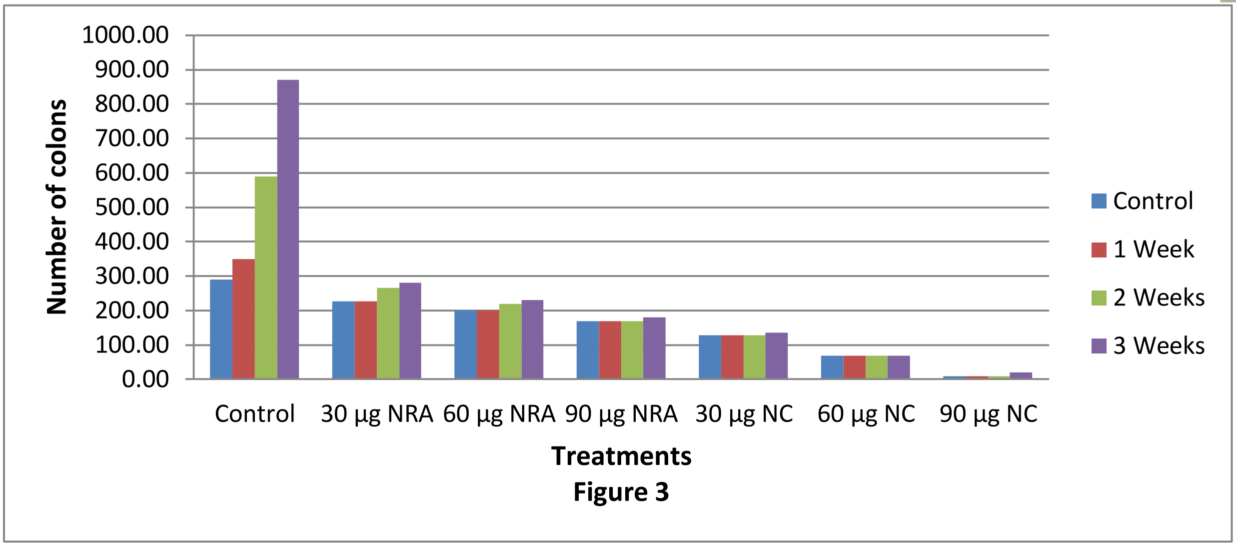

Figure3. Total count microorganisms in the fresh herb of french basil as affected by spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) during 3 weeks storage period in 2017, season.

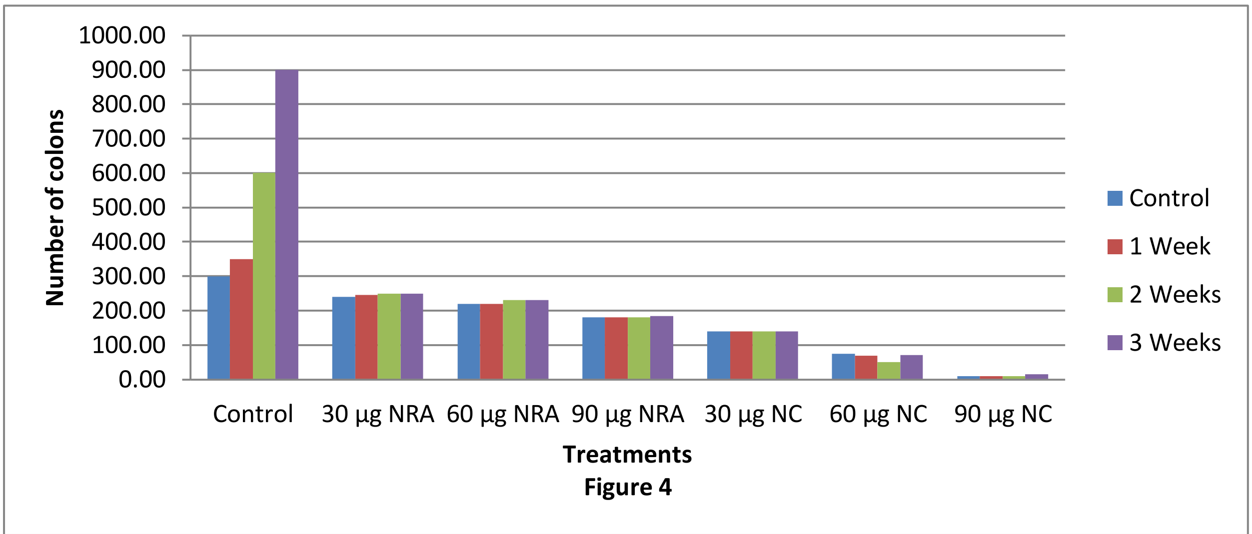

Figure4. Total count microorganisms in the fresh herb of french basil as affected by spraying Nano-curcumin (CU NPs) and Nano-rosemarinic acid (RA NPs) during 3 weeks storage period in 2018, season.

CONCLUSIONS AND DISCUSSIONS

Medicinal and herbal plants, including French basil, are naturally cultured in open fields, resulting in the inconsistency of the biomass production secondary metabolites contents, which are both affected by biotic and abiotic stresses. For that reason, there is an increasing interest in enhancing biomass production and induction of specific secondary metabolite pathways to increase the benefits of these crops. Induction of specific secondary metabolites should follow the instructions for using specific products that should be safe to the human and the environment.

Nanotechnology became one of the most important technologies during this Era and the next one. Application of nanotechnology in agriculture could positively affect the plant growth, secondary metabolites, resistant to different stimuli, yield and different physiological pathways which positively affect the production of active materials and vis-versa. Application of metallic nanoparticles could positively increase the plant resistance to different stimuli, growth, and crop production but also could negatively affect human health because of the cytotoxicity of the metallic nanoparticles. So, going back to Mother Nature became one of the most important solutions for inducing the active materials in the medicinal and herbal plants without harming human being and the environment. Our current research showed that application of Nano-rosemarinic acid (RA NPs) and Nano-curcumin (CU NPs) on the French basil enhanced the photosynthesis rate by increasing leaf area, water and nutrient materials absorption, which impacted in the percentage of chlorophyll, plant height, No. of branches, fresh and dry weight, oil percentage and contents and plant resistance against biotic stress.

Rosmarinic acid is a phenolic compound and ester of caffeic acid, which is naturally present in numerous plants of the Lamiaceae family. Exogenous applications of different concentrations of Nano-rosemarinic acid on French basil showed that, the leaf area , water and nutrient materials absorption, plant height, number of branches, fresh and dry weight, were significantly increased compared to control plants, and slight increase compared to variable concentrations of curcumin nanoparticles. Nano-rosemarinic acid and Nano-curcumin spray-on French basil plants may induce different signaling pathways which led to enhancing the phenotypic characters.

Reactive Oxygen species (ROS) genes are the first defense system which normally induced within few seconds in response both biotic and abiotic stress, also could function as protectants against different stresses and signals activator **Jiang *et al.*, (2007).** Induction of ROS required for full activation of Mitogen-activated protein kinases (MAPKs) genes, which are considered as well characterized families for signalling molecules in higher plants. Also, MAPKs regulate wide range of important and critical cellular processes including cell division, stress responses, metabolism, different developmental processes regulated by hormones and biologically active compounds **Jonak *et al.*, (2002).** Oxidative signal Inducible1 (Oxi1) is a serine/ threonine kinase necessary, a member of AGC of protein kinase family and protein kinase linking ROS accumulation to plant resistance to different stimuli and oxidative burst-mediated signaling in plant roots **Rentel *et al.*, (2004).** Also MAPKs genes very important key player in calcium signaling pathways which control different pathways like stomata opening and closure, callus deposition and seeds germination **Peterson *et al.*, (2009).** MAPKs cascades also can control leaf extension and root length in response to different stimuli and according to our research the applied nanoparticles stimulates MAPKs cascades and enhanced plant growth which resulted from increasing the photosynthesis pathways growth hormones. Also, stimulation of MAPKs cascades led to an increase in trachoma glandular density which affected positively in the phytohormone levels. Nutrient materials and water uptake enhanced as a result of increasing root length and leaf area. Nitrogen uptake, which is considered as an important fundamental constituent of amino acids and enzymes, its sufficiency would positively affect terpenoid biosynthesis. Nitrogen sustains terpenoid productions by improving electron transport rate and photosynthesis process **(Ormeno and Fernandez 2012).**

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