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EFFECT OF PLANT DENSITY AND BICARBONATE/ ACRYLAMIDE NANOCOMPOSITE FOLIAR SPRAY PREPARED BY GAMMA RADIATION ON ONION YIELD AND DISEASES INCIDENCE UNDER SIWA ENVIRONMENTAL CONDITIONS

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ABSTRACT: Nanometric compositions of calcium carbonate, potassium and sodium bicarbonate loaded on polyacrylamide were prepared by using gamma radiation. Size and morphology of the prepared nanocomposite was achieved via using HRTEM. The results revealed the presence of nanoparticles with particle size less than 38 nm. This materials were foliar sprayed as normal or nanoparticles producing six treatments .in addition, ridomil gold plus (chemical fungicide treatment) and tap water treatments. Onion transplants were planted on 7.5 x 7.5, 10 x 10 and 12.5 x 12.5 cm to give a plant population 156, 100 and 68 plants per square meter. The results indicated that, chemical fungicide treatment produced the highest growth characters, highest yield and lowest disease severity and incidence compared with other treatments. The results also confirmed that the use of nanometric compositions of calcium, potassium and sodium as a foliar spray for onion could be a promise treatment in terms of infection with fungal diseases as the results proved the increase of the resistance of onions against fungal diseases by using these nanocomposites. Normal size of this salts increased the vegetative growth characters while its nanocomposites size increased yield. Low plant density gave the highest yield and lowest disease severity and incidence compared with high plant density.

Key words: Bicarbonate, polyacrylamide, gamma radiation, nanocomposites, growth, yield, fungal diseases, disease incidence, disease severity.

INTRODUCTION

Onion (*Allium cepa* L.) is very important vegetable crop in Egypt. It's considered the third follow potatoes and tomatoes in terms of planted area by about 81517 ha. Onion extensively have been consumed as fresh, processed and an indispensable component all over the year. Its production and consumption have been sharply increased in the last decade, especially in Egypt, where planted area increased by fold **(FAOSTAT, 2018)**, though, the production not sufficient because the extensive local and export demand. So, enhancement onion production to ensure the excessive demand are the aim for most researchers. Productivity maximize of planted area are affect by many factors such as agricultural practices, areal diseases and advanced nanoparticles component use. The current global towards is adopt eco-friendly agricultural practices for sustainable development to reduce the problems refer to hazardous chemical pesticides use for crop protection. Moreover, weeds, pests, diseases became more resistant to chemical pesticides as well as environmental pollution and ecological imbalances have been occurred **(Abou-Hussein, 2001 and Gomaa, 2015)**. The development of fungal resistance and environmental pollution are reliance on excessive fungicides application and this problems can be avoid or minimize by using the natural material products such as medicinal plant extracts **(Chaudhary *et al.*, 2003; Abd-El-Khair and Haggag, 2007)** or alkali metal salts **(Abd-El-Kareem, 2007; Labato *et al.*, 2008)**.

In this respect, many researchers studied the suppressive effect of alkali metal salts like (sodium, potassium and calcium salts, sulfur and Phosphite against most aerial diseases on economical crops as an alternative to synthetic fungicides **(Abd-El-Khair and Haggag, 2007; Andreu, 2008; El-Mougy and Abdel-Kader, 2009; Erper, *et al.*, 2011; Hubert *et al.*, 2013; Moushib *et al.*, 2013 and Agha *et al.*, 2016)**. In particular, potassium, sodium bicarbonate has a good control of leaf spot, alternaria leaf blight, gummy stem blight and anthracnose in cucurbits, pythium blight, late blight in potato and powdery mildew of strawberry and soya bean, onion basal rot (**Hofstetter, 1993; Moore, 1996; Williams and Williams, 1992; Anon, 2000; Kuepper *et al.*, 2001, Medice *et al.*, 2013; Turkkan and Erper, 2014 and Shamuyarira *et al.*, 2016)**.

Zaker, (2014) studied the effects of potassium bicarbonate (PB), sodium bicarbonate (SB) and Calcium chloride (CC) against *Fusarium oxysporum*, *Alternaria alternata* and *Botrytis cinerea* causal agents of potato dry rot, tomato leaf spot and grape gray mold respectively. He found that, potassium bicarbonate performed highest antifungal activity against all three pathogens fungi followed by sodium bicarbonate and the best inhibitory effects were achieved by PB (200 mM) followed by SB (200 mM), PB (100 mM) and SB (100 mM) while the least inhibitory effect on all tested fungi was observed by CC (100 mM). Also, potassium, sodium and calcium salts have a significant effect on yield and quality of many vegetables and fruits parallel with its effects as an alternative of fungicides **(Zaman *et al.*, 2019).** Under Egypt conditions, **Zaki *et al.*, (2011)** found that**,** spraying squash plants with sodium or potassium bicarbonate reduced severity of powdery mildew as well as increasing total fruit yield. However, application with 2% of potassium bicarbonate ($KHCO_3$) solution was the best treatment, which significantly increased squash yield compared with sodium bicarbonate or compost tea.

Nanotechnology has wide application in different fields of science and using nanoparticles in promote growth and yield of most crops as well as control of plant diseases is a recent practice. However, whether beneficial or harmful to plant growth is an unresolved issue. So, various studies had revealed a number of the good attempt to understand the impact of nanoparticles on the growth of plants **(Boonyanitipong *et al.*, 2011)**. In this respect, suggested positive impact of NP on plant with its potential to be used as future nanofertilizers **(Lieu *et al.*, 2016)**, calcium phosphate nanoparticles ($CaPO_4$ NPs) exhibit synergistic growth promotion, root proliferation and vitality improvement properties along with endosymbiotic and arbuscular mycorrhizal fungi, which after further field trials can be developed as a cost effective nano-fertilizer with pronounced efficiency **(Rane *et al.*, 2015)**.

More recently, has been an increasing interest in the use of polymer hydrogels (PHG) in agricultural production. PHGs are macromolecular networks with the ability to swell or shrink in the presence or absence of water, due to hydrophilic groups and slightly cross-linked structure which resists dissolution **(Qiu and Hu, 2013)**. Polyacrylamide (PAM) is used as a chemical intermediate in the production of PHGs with high absorption capacity (super-absorbents) such as disposable diapers, medical and agricultural products, among others **(Laftah and Hashim, 2014)**. High molecular weight substances such as PAM added into the soil through irrigation water as anti-erosion additive **(Charoenpanich, 2013)**. Moreover, it has been reported to be degraded by native soil bacterial species such as *Bacillus*, *Pseudomonas* and *Rhodococcus* among others, and also fungi (*Aspergillus*) which are capable of accessing N through amidase activity **(Guezennec *et al.*, 2015)**.

Integrated pest control strategy which include all cultural practices such as rotation, resistant varieties, good air movement, avoid overhead irrigation, decreasing humidity in the crop canopy like wide spacing and moderate fertilizers is very important factors (**Caldwell *et al.*, 2013)**. In particular plant density impact on diseases incidence, many researchers decided that, high density sharply increased foliar diseases severity and incidence (**Mohibullah, 1991** and **Mengesha and Tesfaye, 2015)** especially onion downy mildew disease which caused by *Peronospora destructor* and considered the most economic important disease-causing losses both in the yield and quality of onion particularly when infection has occurred early (**Peter *et al.*, 2004 and Surviliene *et al.*, 2008)**.

The infection occurs systematically when plants are grown from infected bulbs, but local infection partly is caused by air-borne conidia, thus onion bulbs with systemic infection are damaged faster and during moist weather all the leaf surface on infected plants is covered by grayish violet sporulation of *P. destructor*. In case of local infection, oval to cylindrical spots (3–30 mm in size) slightly paler than the rest of foliage are apparent on the leaves. Older leaves are attacked first and infection spreads to other leaves and plants **(Palti, 1989 and Peter *et al.*, 2004)**. Thus, factors affecting on micro climate elements especially relative humidity playing important role on growth, yield and disease severity and incidence of onions. In this respect **Abu Khadrah *et al.*, (2017)** under Delta of Egypt found that, increasing plant density up to 45 plants/m^2 significantly increased most onion vegetative growth characteristics, total and

marketable bulbs yield/fad. and bulb quality compared with 30 or 60 plants/m^2. While, **Attallah** and **Zein El-Abedin (2012)** found that, low density (8 cm between plants) reduced onion bulb yield, but it significantly increased individual bulb weight and bulb diameter compared with high density (4 and 6 cm). Also, **Dawar, *et al.*, (2007)** under Peshawar, Pakistan found that, 40 plants (lower planting density) significantly increased the number of leaves per plant and large bulbs weight, while 80 plants/m^2 (higher planting density) significantly increased leaf length, weight of small bulbs and total yield. While, **kumar *et al*., (2018)** under India conditions found that, tallest onion plants (63.67cm) were obtained from the treatment with spacing 10 cm intra and inter row spacing whereas, total bulb yield was highest in 15x10 spacing. The objective of this study aimed to determine the optimum plant density with trying to find out effective alkali salts even normal or nanoparticles as alternative substances against onion areal diseases and investigate its effects on growth and yield of onion under Siwa oasis conditions.

MATERIALS AND METHODS

Materials: Acrylamide, Orthophosphoric acid (85%) H_3PO_4 (M. W. 98), calcium carbonate, potassium and sodium bicarbonate obtained from Alpha Chemika.

Laboratory experimental part: 18% (v/v) of phosphoric acid was added to an equivalent amount of bi-distelled water then, a detected amount of Acrylamide was added via continuous stirring at 70°C. Finally, after fully mixing of the components, 10% (w/w) of calcium carbonate, potassium and sodium bicarbonate were added to the solution with the continued stirring. The resulted solution was exposed to gamma radiation dose at 1 kGy.

Characterizations: UV – Vis spectrophotometry: The UV-Vis spectra of the prepared nanoparticles were investigated using a UV-Vis spectrophotometer (Evolution 500, Thermo Electron Corporation, England).

High Resolution Transmission electron microscopy (HRTEM): High Resolution Transmission electron microscopy (HRTEM) measurements were performed with (JEOL, JEM 2100, Japan) operating at 200 kV. HRTEM was used to find out the distribution and size of nanoparticles.

Experimental site, treatments and cultivation: The experiments were conducted during two consecutive seasons (2017 - 2018 and 2018-2019) at Siwa Experimental Farm Station, latitude 29º 12’ N, longitude 25º 29’E and 18 meters below sea level, Marsa Matrouh Governorate, Egypt, to study the impact of three transplants density and foliar spray of seven treatments in addition of control treatment on onion production, downy mildew incidence and severity.

Transplants of Giza 20 onion cultivar were transplanting on the 1st of December in both studying seasons. Transplants were transplanting at plant spacing of 7.5 x 7.5, 10 x 10 and 12.5 x 12.5 cm to give a plant population of 156, 100 and 68 plants per square meter (tow irrigation lines were placed to give abundance water then onion transplants were transplanting on 12, 10 and 8 rows respectively). Potassium bicarbonate, nano potassium bicarbonate, sodium bicarbonate, nano sodium bicarbonate, calcium carbonate, nano calcium carbonate, redomil gold plus and tap water as a foliar spray treatment were added by 2 % for all treatments except Ridomil gold plus was added by 2 g / liter. Foliar spray treatments were treated one month after transplanting then repeated every 15 days until three weeks before harvest. The experimental plot was 10.5 m^2 in rows 1 m width under drip irrigation system. In both seasons, all agricultural practices (irrigation, fertilization, weeding) were performed according to the recommendations of the Egyptian Ministry of Agriculture and Land Reclamation. The experiments laid out as a split plot design with three replicates, where, the three-plant density were assessed in main plot and foliar spray treatments were consequently placed in sub plots.

A random sample of 10 plants of each experimental plot were taken at 60 days after transplanting for vegetative growth data *i.e.*, plant height, leaves number and plant fresh weight. At harvest time (Med of April) one quadratic meter was taken from each plot to determine total weight of bulbs, bulb diameter, nick diameter, and total yield per feddan were calculated.

Diseases severity and incidence: both of diseases severity and incidence were assessed at 25% of total plants for every treatment**.** Disease severity was recoded according to (**Parkunan *et al.*, 2013**) as a scale ranged from (0-5), where, 0 = no disease symptoms, 1 = (1-20%), 2 = (21-40%), 3 = (41-60%), 4 = (61-80%), 5 = (81-100%). Disease incidence was determined according to following formula. Disease incidence = (number of diseased plants/total sample number) X100. Reading of disease severity and incidence were taken two times (med. of season and justly after last spray), then average of both were recorded.

Statistical analysis

Data were subjected to statistical analysis by M-STAT C **(Russel, 1991)**. The differences among means were performed using least significant difference (LSD) at 5% level.

RESULTS AND DISCUSSION

High Resolution Transmission Electron Microscopy (HRTEM)

Fig. 1 (a, b) show the high resolution TEM image obtained for the gamma irradiated calcium phosphate nanocomposite. The results reveal the presence of a network of quasi-spherical nanoparticles with particle size of less than 38 nm. Representative TEM images in Figure 1 (a−b) show the uniform distribution of the nanoparticles. Similar results were obtained by **Xu, *et al.*, (2011).** Also, Figure (1c) the inset SAED patterns indicate the calcium phosphate nanoparticles remains amorphous.

UV – Vis spectrophotometry

The preliminary detection of calcium phosphate nanoparticles was performed with the help of UV–visible spectrophotometer. These gamma irradiated calcium phosphate nanoparticles showed the absorbance at (265, 293) nm. (Fig. 2). This similar with **Hou *et al.*, (2013)** who found that, absorbance of calcium phosphate nanoparticles at 230–260 nm synthesized by the chemical method.

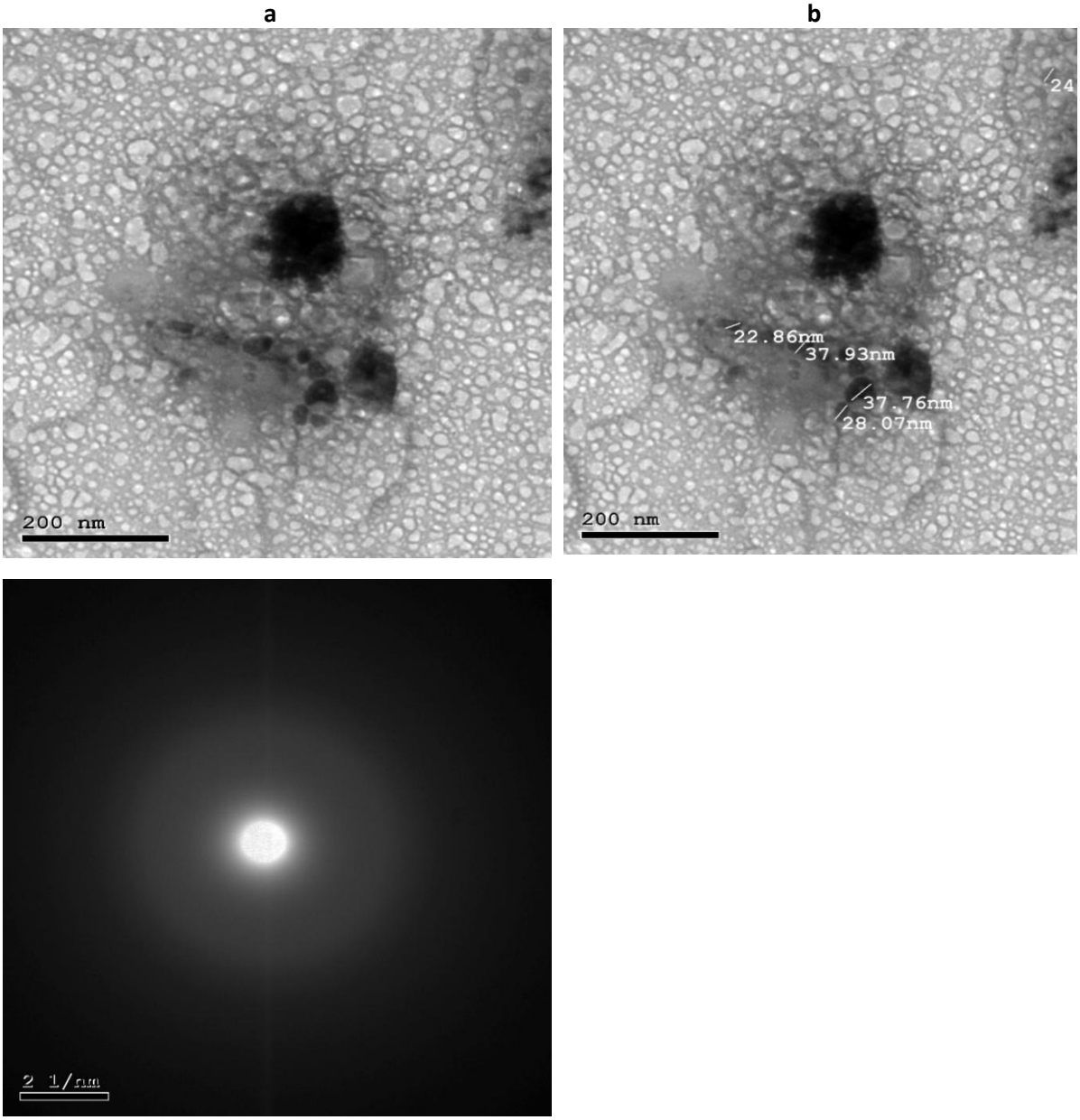

Fig. 1(a, b). TEM images of acrylamide/nano-calcium phosphate composite at 200 nm scales and (c) SAED pattern (inset).

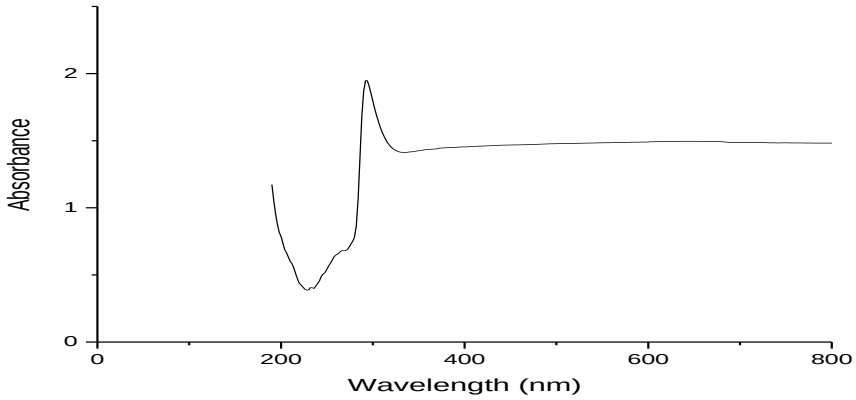

Fig. 2. UV–visible spectrum of the gamma irradiated acrylamide/ nano-calcium phosphate composite showing the absorbance at (265, 293) nm.

Vegetative growth: The influence of transplant density and foliar spray treatments on plant height, leaves number and plant fresh weight on onion plants 60 days after transplanting is given in table (1). High transplanting density (density 3) significantly increased plant height in the first season, while, the effect in the second was not significant. On the contrary, low transplanting density, (density 1) produced the highest leaves number and highest plant fresh weight compared with other plant densities in both seasons. Concerning foliar spray treatments, data presented in table (1) indicated that, redomil (commercial fungicide treatment) produced the highest significant vegetative growth characters followed by potassium bicarbonate then sodium bicarbonate. Control treatment produced the lowest values in this respect followed by calcium carbonate treatment in both seasons. Also, data in table 1, showed slight superiority of alkali salts (potassium bicarbonate and calcium carbonate) as a normal size compared with nano size of its salts, while the opposite trend was evident with sodium bicarbonate in both seasons. Regarding interaction effects, data presented in table 2, showed that, onion plant height and plant fresh weight significantly affected, while leaves number was not significant. High density of onion transplants treated with redomil fungicide followed by potassium bicarbonate produced the highest plants, while the same treatments, gave the heaviest plant fresh weight when transplanting on low density. On the other hand, control treatment with low and high density significantly produced the lowest plant height and plant fresh weight respectively in both seasons.

Table 1. The effect of different transplant densities, foliar spray on onion plant height (cm), leaves number and plant fresh weight (g)

Parameters	Plant height (cm)		Leaves number		Plant fresh weight (g/plant)	
Seasons / Treatments	1st	2nd	1st	2nd	1st	2nd
Plant density						
Density one	48.99	58.99	7.37	7.87	56.28	71.93
Density tow	52.10	55.98	6.41	6.92	53.16	69.49
Density three	53.53	58.76	5.81	6.30	49.81	65.77
LSD at 0.05	**2.48**	**N.S**	**0.09**	**0.06**	**1.50**	**2.03**
Foliar spray treatments						
Potassium bicarbonate	55.49	61.81	6.77	7.37	57.39	72.07
Nano potassium bicarbonate	52.65	60.38	6.84	7.34	54.78	70.79
Sodium bicarbonate	51.49	56.93	6.56	7.08	52.15	67.53
Nano of sodium bicarbonate	53.87	60.67	6.69	7.12	54.36	71.35
Calcium carbonate	50.41	57.52	6.30	6.75	53.24	69.01
Nano of calcium carbonate	51.25	57.36	6.15	6.56	52.12	68.16
Ridomil gold plus	58.45	63.53	7.13	7.71	59.36	76.70
Control	38.69	45.11	5.80	6.33	41.30	56.89
LSD at 0.05	**1.47**	**1.61**	**0.12**	**0.16**	**1.54**	**2.04**

Table 2. The effect of interaction between plant densities and foliar spray on onion plant height (cm), leaves number and plant fresh weight (g)

Parameters		Plant height (cm)		Leaves number		Plant fresh weight (g/plant)	
Treatments \ Seasons		1st	2nd	1st	2nd	1st	2nd
Density 1	Potassium bicarbonate	52.82	63.23	7.60	8.20	60.29	73.66
	potassium bicarbonate Nano	51.14	58.67	7.60	8.17	55.64	70.30
	Sodium bicarbonate	45.86	56.45	7.40	7.97	53.50	68.12
	Nano of sodium bicarbonate	52.47	61.73	7.45	7.95	55.73	74.06
	Calcium carbonate	50.29	58.65	7.28	7.72	57.32	72.99
	Nano of calcium carbonate	50.74	61.92	7.15	7.41	57.91	73.58
	Ridomil gold plus	54.38	62.40	7.90	8.45	63.08	80.84
	Control	34.18	48.92	6.54	7.11	46.80	61.92
Density 2	Potassium bicarbonate	55.42	58.83	6.56	7.26	57.22	72.55
	potassium bicarbonate Nano	54.45	59.80	6.75	7.23	54.46	72.13
	Sodium bicarbonate	58.13	52.20	6.53	6.94	49.54	65.88
	Nano of sodium bicarbonate	53.71	59.92	6.67	7.01	55.60	72.92
	Calcium carbonate	48.62	57.90	6.10	6.58	55.39	71.72
	Nano of calcium carbonate	46.38	57.43	5.95	6.44	53.77	70.45
	Ridomil gold plus	60.49	61.25	6.99	7.65	59.48	74.10
	Control	39.58	40.50	5.72	6.25	39.83	56.17
Density 3	Potassium bicarbonate	58.23	63.37	6.16	6.64	54.66	70.00
	potassium bicarbonate Nano	52.37	62.67	6.16	6.61	54.25	69.92
	Sodium bicarbonate	50.47	62.13	5.76	6.32	53.40	68.60
	Nano of sodium bicarbonate	55.43	60.37	5.95	6.39	51.75	67.08
	Calcium carbonate	52.31	55.99	5.50	5.96	47.00	62.33
	Nano of calcium carbonate	56.64	52.74	5.33	5.82	44.66	60.45
	Ridomil gold plus	60.47	66.93	6.50	7.03	55.52	75.17
	Control	42.31	45.92	5.15	5.63	37.26	52.59
LSD at 0.05		**2.94**	**3.22**	**N.S**	**N.S**	**3.08**	**4.08**

Our results are agreed with **Dawar *et al.*, 2007**; **Abu Khadrah *et al.*, 2017**; **kumar *et al.*, 2018** whose decided that, lower planting density significantly increased the number of leaves per plant while higher planting density significantly increased leaf length. Also, **Zaki *et al.*, 2011 and Zaman *et al.*, 2019** reported that, potassium, sodium and calcium salts have a significant effect on yield and quality of many vegetables and fruits parallel with its effects as an alternative of fungicides.

Yield and its component: Data presented in table 3, showed that, onion yield (kg/ fed.) and bulb diameter significantly affected by plant density and foliar spray treatments in both seasons, while nick diameter was only significant in the first season. Low plant density (density 1) produced the highest onion yield followed by middle density (density 2) while, high density (density 3) produced the lowest significant onion yield in both seasons. Ridomil (commercial fungicide treatment significantly produced the highest yield compared with other foliar application treatments followed by nano potassium bicarbonate and nano sodium bicarbonate in the first and second seasons respectively. On the other hand, control treatment

produced the lowest onion yield in both seasons. Concerning bulb diameter, ridomil treatment gave the highest value compared with other treatments, especially control treatment which gave the lowest value in this respect. Nick diameter in the second season was significant, while in the first one, results gave opposite trend, where, high density gave the highest nick diameter compared with other densities.

Also, as opposite trend with vegetative growth characters, where potassium, sodium and calcium salts as a normal size gave relatively lower yield compared with nano size of this salts. Regarding interaction effects on onion yield and bulb diameter in both seasons, ridomil (commercial fungicide treatment) produced the highest yield when onion transplanting on low density followed by the same treatment with middle density then high density of transplanting. Control treatment with high density produced the lowest yield followed by calcium carbonate, sodium bicarbonate and nano calcium carbonate with high density transplanting in both seasons. The same trend was found with bulb diameter character, while the effect of interaction on nick diameter was not significant. Also, presented data showed that, ridomil treatment effect was relatively constant with all transplanting densities compared with alkali salts effects which relatively decreased when transplants density increasing. Many researchers in previous studies reported that potassium, sodium and calcium salts have significant effects on yield and quality of many vegetables and fruits parallel with its effects as an alternative of fungicides, e.g., Kinnow fruit and squash **(Zaki *et al.*, 2011**; **Zaman *et al.*, 2019;)**. Moreover, increasing plant density up to 45 plants/m^2 significantly increased total and marketable bulbs yield/fad and bulb quality compared with 30 or 60 plants/m^2 (**Abu Khadrah *et al.*, (2017**), 40 plants /m^2 (lower planting density) significantly increased large bulbs weight while, 80 plants/m^2 (higher planting density) significantly increased total yield **(Dawar, *et al.*, (2007)**, total bulb yield was highest in 15x10 spacing (**kumar *et al.*, 2018)**.

Table 3. The effect of different transplant densities, foliar spray on onion yield (kg/fed.), bulb diameter (cm) and nick diameter (cm)

Parameters	Onion yield (kg/fed.)		Bulb diameter (cm)		Nick diameter (cm)	
Seasons / Treatments	1st	2nd	1st	2nd	1st	2nd
Plant density						
Density one	8850	10756	6.59	7.18	1.60	1.73
Density tow	8359	9494	6.35	6.89	1.57	1.74
Density three	7188	7763	5.94	6.46	1.67	1.75
LSD at 0.05	**134**	**195**	**0.09**	**0.08**	**0.03**	**N.S**
Foliar spray treatments						
Potassium bicarbonate	8027	8983	6.44	6.96	1.64	1.75
Nano potassium bicarbonate	8295	9396	6.45	6.98	1.62	1.74
Sodium bicarbonate	7789	8686	6.22	6.72	1.63	1.74
Nano of sodium bicarbonate	8064	9619	6.36	6.89	1.61	1.74
Calcium carbonate	7633	8828	5.94	6.49	1.58	1.72
Nano of calcium carbonate	7648	9054	6.17	6.63	1.59	1.71
Ridomil gold plus	10518	12326	7.16	7.99	1.67	1.79
Control	7087	7807	5.60	6.08	1.57	1.70
LSD at 0.05	**104**	**188**	**0.08**	**0.08**	**0.03**	**N.S**

Table 4. The effect of interaction between densities and foliar spray on onion yield (kg/fed.), bulb diameter (cm) and nick diameter (cm)

Parameters		Onion yield (kg/fed.)		Bulb diameter (cm)		Nick diameter (cm)	
Treatments \ Seasons		1st	2nd	1st	2nd	1st	2nd
Density 1	Potassium bicarbonate	8743	10529	6.77	7.34	1.62	1.74
	potassium bicarbonate Nano	9053	11191	6.81	7.34	1.60	1.71
	Sodium bicarbonate	8301	9754	6.58	7.03	1.66	1.72
	Nano of sodium bicarbonate	8549	11267	6.71	7.23	1.59	1.73
	Calcium carbonate	8627	10469	6.25	6.84	1.56	1.71
	Nano of calcium carbonate	8177	10499	6.58	7.07	1.54	1.68
	Ridomil gold plus	11021	13426	7.22	8.21	1.68	1.80
	Control	8330	8911	5.82	6.33	1.54	1.72
Density 2	Potassium bicarbonate	8198	9275	6.56	7.04	1.61	1.77
	potassium bicarbonate Nano	8543	9662	6.52	7.05	1.57	1.76
	Sodium bicarbonate	8305	8529	6.29	6.84	1.56	1.74
	Nano of sodium bicarbonate	8409	9658	6.44	6.99	1.57	1.76
	Calcium carbonate	7807	9046	5.99	6.54	1.54	1.72
	Nano of calcium carbonate	7941	9250	6.24	6.66	1.57	1.71
	Ridomil gold plus	10405	12267	7.20	7.94	1.64	1.79
	Control	7268	8261	5.55	6.09	1.54	1.67
Density 3	Potassium bicarbonate	7141	7145	5.99	6.51	1.67	1.75
	potassium bicarbonate Nano	7290	7335	6.03	6.56	1.67	1.75
	Sodium bicarbonate	6762	7775	5.77	6.29	1.67	1.75
	Nano of sodium bicarbonate	7233	7934	5.94	6.46	1.67	1.75
	Calcium carbonate	6465	6969	5.59	6.09	1.65	1.73
	Nano of calcium carbonate	6824	7414	5.70	6.16	1.67	1.75
	Ridomil gold plus	10129	11284	7.06	7.81	1.69	1.77
	Control	5663	6250	5.44	5.82	1.63	1.71
LSD at 0.05		**209**	**376**	**0.16**	**0.16**	**N.S**	**N.S**

Disease severity and incidence: Downy mildew disease severity and incidence: data presented in table5, showed that, downy mildew severity differed among plant density and foliar spray treatments in both seasons. Low plant density, showed the lowest disease severity of downy mildew on onion plants compared with middle or high plant density in two seasons. Regarding foliar spray effect, chemical fungicide treatment (Ridomil plus) gave the lowest disease severity compared with other treatments, followed by both sodium treatments in the first season or by sodium bicarbonate and nano calcium carbonate in the second season. While, control treatment gave the highest disease severity followed by other salt treatments in both seasons. Concerning of downy mildew incidence, data in table 6, revealed that, low plant density significantly reduced the disease incidence followed by middle density then high density in both seasons. The downy mildew disease incidence was (26.34), (42.67) and (79.21) percent for low, middle and high density in first season respectively, while recorded (33.50), (46.79) and (78.67) percent in the second season. Chemical fungicide treatment (ridomil plus) significantly reduced disease incidence compared with other foliar spray treatments in both seasons. Nano calcium carbonate, nono potassium bicarbonate and nano sodium bicarbonate significantly reduced disease incidence, followed by calcium carbonate, sodium and potassium bicarbonate in first season, while in the second seasons nano sodium bicarbonate, nano calcium carbonate and nano potassium bicarbonate gave the lowest disease incidence after chemical treatment. On the other hand, normal size of it salts gave the highest percent of disease incidence after control treatment in both seasons. All interaction effects were significant in both seasons. The most pronounced interaction effects were, increasing downy mildew severity and incidence when onion transplanted on high density with control treatment, followed by normal size of alkali salts treatments with high density as compared with low transplants density especially when treated with chemical fungicide or nano particles size of alkali salts in both seasons. The suppression of downy mildew disease severity and incidence on onion plants because chemical treatment is similar with **Surviliene *et al*. (2008)**. Plant density was identified as major factors affecting downy mildew **Gonzalez *et al*. (2011)**. Also, many researchers reported that, development of downy

mildew has strong correlation with weather conditions especially relative humidity which considered the most important factor for development and produce the greatest number of sporangia. High density increases disease severity and incidence and this may be due to increase the relative humidity (RH) between plants, **(Gilles *et al.*, 2004)**. Decreasing of downy mildew incidence and severity by nanoparticles of alkali salts compared with control are agreement with **Fadel *et al.*, 2015**; **Soubeih and Agha (2019)**, who reported that, downy mildew significantly decreased with increasing silicon dioxide (SiO_2) and titanium dioxide (TiO_2) nanoparticles NPs sprayed separate or in combination compare with traditional practices on plant ability to resist fungal diseases.

Table 5. The effect of different transplant densities, foliar spray and interaction on onion downy mildew disease severity

Downy mildew severity								
	First season				Second season			
Treatments	**Density 1**	**Density 2**	**Density 3**	**Mean**	**Density 1**	**Density 2**	**Density 3**	**Mean**
Potassium bicarbonate	2	3	4	**3.00**	2	3	4	**3.00**
Nano potassium bicarbonate	2	3	4	**3.00**	2	3	4	**3.00**
Sodium bicarbonate	2	3	3	**2.67**	2	3	3	**2.67**
Nano sodium bicarbonate	2	3	3	**2.67**	2	4	4	**3.33**
Calcium carbonate	2	3	4	**3.00**	2	4	4	**3.33**
Nano calcium carbonate	2	3	4	**3.00**	2	3	3	**2.67**
Ridomil plus	1	2	2	**1.67**	1	2	2	**1.67**
Control	3	4	5	**4.00**	3	4	5	**4.00**
Mean	**2.00**	**3.00**	**3.63**	**2.88**	**2.00**	**3.25**	**3.63**	**2.96**

Table 6. The effect of different transplant densities, foliar spray and interaction on onion downy mildew disease incidence %

Downy mildew incidence %								
	First season				Second season			
Treatments	**Density 1**	**Density 2**	**Density 3**	**Mean**	**Density 1**	**Density 2**	**Density 3**	**Mean**
Potassium bicarbonate	34.67	40.33	95.00	**56.67**	36.00	43.00	96.67	**58.56**
Nano potassium bicarbonate	25.67	32.00	90.00	**49.22**	30.67	37.33	94.17	**54.06**
Sodium bicarbonate	23.33	44.00	90.83	**52.72**	29.33	49.33	89.17	**55.94**
Nano sodium bicarbonate	23.00	34.67	85.83	**47.83**	20.33	47.33	82.50	**40.05**
Calcium carbonate	22.67	50.67	82.50	**51.95**	33.00	52.00	77.50	**54. 17**
Nano calcium carbonate	21.67	44.67	69.17	**45.17**	32.67	50.00	65.83	**49.50**
Ridomil plus	7.37	15.00	23.67	**15.35**	19.33	14.00	26.00	**19.78**
Control	52.33	80.00	96.67	**76.33**	66.67	81.33	97.50	**81.83**
Mean	**26.34**	**42.67**	**79.21**		**33.50**	**46.79**	**78.67**	
LSD at 0.05 for density				**2.33**				**4.80**
LSD at 0.05 for foliar spray				**3.51**				**2.80**
LSD at 0.05 for interaction				**7.02**				**5.61**

Conclusion

Using nanometric compositions of calcium, potassium and sodium as a foliar spray for onion could be a promise treatments in terms of infection with fungal diseases as the results proved increasing onion resistance against this diseases. Although using normal salts increased the vegetative growth characters, its nanocomposites increased yield. Low plant density gave the highest yield and lowest disease severity and incidence compared with high plant density. But in general, using nanoparticles of calcium, potassium and sodium salts are promise treatments to enhancement onion growth and yield. In addition, decreasing disease severity and incidence provided that occurred more future chemicals and anatomy studies.

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