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EFFECT OF HUMIC ACID APPLICATION, CHITOSAN AND ARMUROX ANTITRANSPIRANT SPRAY ON GROWTH AND FRUITING CHARACTERISTICS OF POMEGRANATE CV.SALIMI TREES

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ABSTRACT

This experience was carried out in a private orchard in the village of Otomaniyah, Diyala governorate, during the growing season 2019 to study the Effect of soil application of Humic acid, Chitosan and Armurox antitranspirant spray on growth and fruiting of characteristics of 6 years old pomegranate trees cv. Salimi . Humic acid applied to the soil at three levels (0, 10 and 20 gm per plant). Chitosan and applied as foliar spray at three conc. Chitosan at (0, 250 and 500 mg per liter), Armurox (0, 2.5 and 5 ml per liter). The results showed a progressive improvement in most of growth and yield studied traits as a result of these material application, and spray (alone or in combination) as well as these treatments reduced fruit drop percent.

Keywords : Pomegranate, HA, Chitosan, Armurox, fruiting characteristics

Introduction

Pomegranate belongs to the family *Punicaceae,* and the genus *Punica,* the best fruit was found in Carthage (also called Punica by the Romans) hence the scientific name *Punica granatum* (Akpinar bayizit *et al*., 2012; Mir *et al*., 2012). It is a subtropical fruit tree crop cultivated in numerous subtemperate, temperate, tropical, and subtropical regions throughout the world (Verma *et al*., 2010). Due to the rapid increase in the production, it is highly difficult to calculate the world total production. The top countries for the production of pomegranate are believed to be: India, Iran, Turkey, China, United States of America, Israel, Egypt, Spain, Afghanistan, Tunisia, Azerbaijan, Morocco, Argentina, Brazil, Chile, Peru, South Africa, Australia, and Italy (Kahramanoğlu, 2019). Applying some soil conditioners and biostimulants such as humic acid (HA) and effective microorganisms (EM) to the soil is very important in agro management due to the beneficial effects on the physical, chemical and biological properties of the soil (Belal,2015). Humic acid is essential in soil organic matter which is crucial for maintaining soil fertility, which has positive impact on biological, chemical and physical properties of the soils. In addition, the nature stability of these substances affects carbon and nitrogen cycles and carbon sequestration (Soliman *et al*., 2017). It is produced by biodegradation of dead organic bodies. It is not a single acid, rather, it is a heterogeneous mixture of many compounds generally similar chemical properties. It plays important roles for soil and plant growth, one of the functions of (HA) is the promotion of root development (Rengrudkij and Partida, 2003). The mechanism of (HA) activity in promoting plant growth is not completely known, but several explanations have been proposed by some researchers such as increasing cell membrane permeability, oxygen uptake, chlorophyll density, plant root respiration and photosynthesis, phosphate uptake, and root cell elongation (Turkmen *et al.,* 2004).

Chitosan (CHT) chemically a linear unbranched polymer of -1,4-D-glucosamine, is obtained from chitin, a co-polymer of N-acetyl-D glucosamine and D-glucosamine constituting the main component of the exoskeleton of arthropods (Malerba and Cerana, 2018), It is non-toxic, biodegradable and biocompatible which favors potentially broad application. It enhances the physiological response and mitigates the adverse effects of abiotic stresses through stress transduction pathway via secondary messenger. Chitosan treatment stimulates photosynthetis rate, stomatal closure through ABA synthesis; enhances antioxidant enzymes via nitric oxide and hydrogen peroxide signaling pathways, and induces production of organic acids, sugars, amino acids and other metabolites which are required for the osmotic adjustment, stress signaling, and energy metabolism under stresses. (Hidangmayum *et al.,* 2019).

Anti-transpirants are the materials or chemicals which decrease the water loss from plant leaves by reducing the size and number of stomata. Nearly 99 per cent of the water absorbed by the plant is lost in transpiration. Antiranspirants and is any natural applied to transpiring plant surfaces for reducing water loss from the plant. There are of four types Stomatal closing type, film forming type, reflectance type and growth retardant (Gaballah *et al.,* 2014).

Materials and Methods

The experiment was carried out in a private orchard in the Othmaniyah area, Diyala Governorate on 5-Yrs Pomegranate cv. Salimi trees (3.5*4m apart) to investigate the effects of applying Humic acid at three concentrations (0, 10, and 20g per tree),and foliar spray of chitosan (0, 250, and 500mg l^{-1}), and antitranspirant Armoux at three concentrations (0, 2.5 and 5 ml l^{-1}) A factorial experiment with three factors (3×3×3) were used in Randomized Complete Block design (RCBD) with three replicates and two trees per experimental unit. Results were analyzing using Duncan's multiple range test at 0.05 probability.

Table 1 : Shows some physical and chemical characteristics of field soil

Texture	O.M%	B mg.kg^{-1}	K mg.kg^{-1}	P mg.kg^{-1}	N mg.kg^{-1}	Ca meq/L	pH	EC ds/m
loam	**0.7**33	0.692	111	8.34	43.17	18	7.25	1.98

*Soil was analyzed in the Central Soil Laboratory, College of Agriculture, University of Baghdad

The studied characters include:

1. Leaves mineral contents: Dried peel samples were grounded and digested with H_2SO_4, and N, P, K were determined as follows: nitrogen was determined by spectrophotometer (Novozamsky *et al.*, 1974), P by spectrophotometer (Van Schouwenberg and Walinga, 1967), K by flame photometer (Tendon, 2005). 2. Leaf content of chlorophyll was determined by spectrophotometer (Suha, 2011). 3. Perfect flowers (%) 4. Fruits set (%) 5. Fruit drop (%) 6. Total yield per tree (kg) 7. No. of fruits per tree

Results and Discussion

Results in table 2-5 showed that there is a positive increase in leaf content of N, P, K and chlorophyll combined with increasing HA dose (alone or in combination), Chitosan and Armurox (alone or in combination), application compared with untreated trees.

The reason for the increase in leaves' minerals content, nitrogen (Table 2), phosphorous (Table 3) and potassium (Table 4), with HA application may be due to it’s role in increasing these nutrients availability as a result its effect on increasing the organic matter in the soil, which works to improve the physical, chemical, and soil fertility, and the ion exchange capacity furthermore HA act as a chelating substance that limits the loss and precipitation of nutrients, by reducing the soil pH in the root zone (Al-Shater *et al.*, 2011).

The increase in leaf content of the mineral elements (nitrogen, phosphor, potassium), and chlorophyll as a result of chitosan spray may be due to its phytohormones content like cytokinin (Gawar, 2019), which increases the root system branches (by stimulating cells division), and root system volume, which is reflected positively in the increase of nutrient absorption and their accumulation in the leaves (Tables 2-5). These results are in line with the findings of Dzung *et al*. (2011) when coffee seedlings were sprayed with different levels of Chitosan.

The increase in leaves mineral and chlorophyll content with spraying of anti-transpiration Armorux may be due to the fact that it contains silicon, which has a role in the absorption of nutrients, especially potassium, which has a direct effect on the permeability and stability of cell membranes and the osmotic state of cells through it’s effect in regulating the action of the enzyme H^+-ATPase (Liang, 1999), which controls the electrochemical state of the cells responsible for the processes of free and active absorption and transport, as well as the role of silicon in the development of roots (Kong *et al*., 2001), which is reflected in the increased absorption of elements by the roots and their transfer to the leaves.

HA application and the spray of Chitosan (alone or in combination), and Armurox spray (alone or with HA application) treatments increased significantly hermaphrodite flowers percent, No. of fruits per tree, Total yield per tree (kg), compared with untreated trees (tables 6,7,9,10), whereas HA application and the spray of Chitosan (alone or in combination), and Armurox spray (alone or with HA application) treatments and the interaction between Chitosan with Armurox spray reduced significantly fruits drop present compared with untreated trees which gave the highest present (Table 8).

The increase in the hermaphrodite flowers, fruit set, reducing fruits drop, the number of persistent fruits percentage, and the total yield per plant resulting from HA application , spraying with Chitosan, or Armurox alone may be due to their role in increasing leave’s mineral (Tables 2-4), chlorophyll content (Table5), and their effects in increasing photosynthesis products which reflect positively on flowers induction and fruits set , where nutrient deficiency is one of the main reasons for the failure of fruit set and the transformation of the flower into a fruit (Jundeia, 2003).

Table 2: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on Nitrogen content in leaves during 2019 growing season

HA (g tree^{-1})	Chitosan (mg l^{-1})	Armurox (ml l^{-1}) 0	Armurox (ml l^{-1}) **2.5**	Armurox (ml l^{-1}) 5	HA x Chitosan
0	0	1.68 f	1.77 e	1.81 de	1.75 e
	250	1.81 de	1.83 c-e	1.82 c-e	1.82 d
	500	1.82 c-e	1.83 c-e	1.85 b-e	1.83 cd
10	0	1.89 a-d	1.89 a-d	1.86 b-e	1.88 a-c
	250	1.89 a-d	1.92 a-c	1.87 b-d	1.89 ab
	500	1.86 b-e	1.87 b-d	1.86 b-e	1.86 b-d
	0	1.83 c-e	1.91 a-d	1.91 ad	1.88 a-c

20	250	1.90 a-d	1.91 a-d	1.88 b-d	1.89 a-b
	500	1.94 ab	1.98 a	1.86 b-e	1.93 a
					HA
HA× Armurox	0	1.77 e	1.81 de	1.83 de	1.80 B
	10	1.88 ab	1.89 ab	1.86 bc	1.88 A
	20	1.89 ab	1.93 a	1.88 ab	1.90 A
					Chitosan
Chitosan × Armurox	0	1.80 b	1.86 a	1.86 a	1.84 B
	10	1.87 a	1.89 a	1.86 a	1.87 A
	20	1.87 a	1.89 a	1.86 a	1.87 A
Armurox		1.85 B	1.88 A	1.86 AB	

Table 3: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on Leaf content of Phosphorus during 2019 growing season

HA (g tree^{-1})	Chitosan (mg l^{-1})	Armurox (ml l^{-1})			HA x Chitosan
		0	**2.5**	5	
0	0	0.172 g	0.181 e-g	0.182 e-g	0.178 e
	250	0.180 e-g	0.177 fg	0.182 e-g	0.180 e
	500	0.182 e-g	0.181 e-g	0.181 e-g	0.181d e
10	0	0.183 e-g	0.182 e-g	0.199 b-d	0.188 d
	250	0.198 b-d	0.209 ab	0.193 b-d	0.201 bc
	500	0.203 b-d	0.190 d-f	0.204 b-d	0.199 bc
20	0	0.200 b-d	0.193 c-e	0.194 c-e	0.196 c
	250	0.199 b-d	0.206 a-c	0.206 a-c	0.204 b
	500	0.208 a-c	0.208 a-c	0.220 a	0.212 a
					HA
HA× Armurox	0	0.178 d	0.180 d	0.182 d	0.180 C
	10	0.194 c	0.194 c	0.199 a-c	0.196 B
	20	0.202 ab	0.202 ab	0.206 a	0.204 A
					Chitosan
Chitosan × Armurox	0	0.185 c	0.185 c	0.192 bc	0.188 B
	10	0.192 bc	0.197 ab	0.194 ab	0.194 A
	20	0.198 ab	0.193 bc	0.202 a	0.197 A
Armurox		0.192 B	0.192 B	0.196 A	

Table 4: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on Leaf content of potassium during 2019 growing season

HA ($g\ tree^{-1}$)	**Chitosan ($mg\ l^{-1}$)**	**Armurox ($ml\ l^{-1}$)**			**HA x Chitosan**
		0	**2.5**	5	
0	0	1.70 j	1.74 ij	1.78 h-j	1.74 f
	250	1.82 hi	1.84 h	1.83 hi	1.83 e
	500	1.83 hi	1.87 hj	1.84 hi	1.85 e
10	0	1.98 d-g	1.96 fj	1.97 fg	1.97 d
	250	2.03 b-f	2.08 a-e	2.02 c-f	2.04 c
	500	2.10 a-d	2.10 a-d	2.05 a-f	2.08 bc
20	0	2.05 a-f	2.09 a-e	2.11 a-c	2.08 bc
	250	2.13 a-c	2.13 a-c	2.15 ab	2.14 ab
	500	2.14 ab	2.17 a	2.16 a	2.16 a
					HA
HA× Armurox	0	1.78 c	1.82 c	1.82 c	1.81 C
	10	2.04 b	2.05 b	2.01 b	2.03 B
	20	2.11 a	2.13 a	2.14 a	2.13 A
					Chitosan
Chitosan × Armurox	0	1.91 c	1.93 c	1.95 bc	1.93 B
	10	1.99 ab	2.02 ab	2.00 ab	2.00 A
	20	2.02 ab	2.05 a	2.02 ab	2.03 A
Armurox		1.98 A	2.00 A	1.99 A	

Table 5: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on Leaf content of chlorophyll during 2019 growing season

HA ($g\ tree^{-1}$)	**Chitosan ($mg\ l^{-1}$)**	**Armurox ($ml\ l^{-1}$)**			**HA x Chitosan**
		0	**2.5**	5	
0	0	9.75 k	10.81 j	11.12 j	10.56 h
	250	10.94 j	11.21 j	12.92 i	11.69 g
	500	12.88 i	12.98 i	13.14 i	13.00 f
10	0	13.87 h	14.21 gh	14.53 g	14.20 e
	250	14.50 g	14.99 f	15.93 e	15.14 d
	500	16.10 e	16.72 d	17.08 d	16.63 c
20	0	17.95 c	17.89 c	18.05 bc	17.96 b
	250	17.90 c	18.36 a-c	18.48 ab	18.25 a
	500	18.61 a	18.58 a	18.28 a-c	18.49 a

					HA
HA× Armurox	0	11.19 g	11.67 f	12.39 e	11.75 C
	10	14.82 d	15.31 c	15.85 b	15.32 B
	20	18.15 a	18.27 a	18.27 a	18.23 A
					Chitosan
Chitosan × Armurox	0	13.86 g	14.30 f	14.56 e	14.24 C
	10	14.45 ef	14.85 d	15.77 c	15.02 B
	20	15.86 bc	16.09 ab	16.17 a	16.04 A
Armurox		14.72 C	15.08 B	15.50 A	

Table 6: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on hermaphrodite flowers percent during 2019 growing season

HA (g tree^{-1})	**Chitosan (mg l^{-1})**	**Armurox (ml l^{-1})**			**HA x Chitosan**
		0	**2.5**	5	
0	0	28.50 d	30.65 b-d	30.04 cd	29.73 c
	250	31.06 a-d	34.30 a	32.29 a-c	32.55 ab
	500	31.07 a-d	30.90 a-d	31.46 a-d	31.14 bc
10	0	31.40 a-d	31.81 a-d	31.74 a-d	31.65 ab
	250	31.89 a-d	31.97 a-d	32.14 a-c	32.00 ab
	500	31.95 a-d	32.36 a-c	30.93 a-d	31.75 a
20	0	32.33 a-c	32.63 a-c	32.35 a-c	32.44 ab
	250	32.05 a-c	31.92 a-d	32.62 a-c	32.20 ab
	500	32.71 a-c	32.74 a-c	34.15 ab	33.20 a
					HA
HA× Armurox	0	30.21 b	31.95 ab	31.26 ab	31.14 B
	10	31.75 ab	32.05 ab	31.60 ab	31.80 AB
	20	32.36 a	32.43 a	33.04 a	32.61 A
					Chitosan
Chitosan × Armurox	0	30.74 b	31.70 ab	31.38 ab	31.27 A
	250	31.67 ab	32.73 a	32.35 ab	32.45 A
	500	31.91 ab	32.00 ab	32.18 ab	32.03 A
Armurox		31.44 A	32.14 A	31.97 A	

Table 7: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on fruits set percent during 2019 growing season

HA (g tree^{-1})	Chitosan (mg l^{-1})	Armurox (ml l^{-1}) 0	2.5	5	HA x Chitosan
0	0	7.84 e	9.60 c-e	10.71 a-d	9.38 c
	250	10.78 a-d	9.38 de	10.62 a-d	10.26 bc
	500	10.72 a-d	11.78 a-d	11.30 a-d	11.26 ab
10	0	11.82 a-d	11.86 a-d	12.43 a	12.04 a
	250	11.74 a-d	12.24 ab	12.32 ab	12.10 a
	500	9.83 b-e	10.98 a-d	10.18 a-d	10.33 bc
20	0	12.04 a-c	11.56 a-d	11.80 a-d	11.80 a
	250	11.70 a-d	11.66 a-d	11.31 a-d	11.56 ab
	500	11.34 a-d	11.24 a-d	11.43 a-d	11.34 ab
					HA
HA× Armurox	0	9.78 c	10.25 bc	10.88 ac	10.30 B
	10	11.13 ab	11.69 a	11.64 a	11.49 A
	20	11.70 a	11.49 ab	11.51 ab	11.56 A
					Chitosan
Chitosan × Armurox	0	10.57 a	11.00 a	11.64 a	11.07 A
	250	11.41 a	11.09 a	11.42 a	11.30 A
	500	10.63 a	11.33 a	10.97 a	10.97 A
Armurox		10.87 A	11.14 A	11.34 A	

Table 8: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on Fruits drop (%) during 2019 growing season

HA (g tree^{-1})	Chitosan (mg l^{-1})	Armurox (ml l^{-1}) 0	2.5	5	HA x Chitosan
0	0	17.53 a	7.47 b	7.29 b	10.76 a
	250	6.32 b	7.56 b	8.78 b	7.55 b
	500	7.40 b	7.44 b	7.51 b	7.45 b
10	0	7.23 b	7.41 b	6.62 b	7.09 b
	250	6.51 b	7.49 b	6.94 b	6.98 b
	500	7.86 b	7.40 b	7.75 b	7.67 b
20	0	7.34 b	8.91 b	8.22 b	8.16 b
	250	8.99 b	7.99 b	8.88 b	8.62 b
	500	8.81 b	7.61 b	7.05 b	7.82 b
					HA

HA× Armurox	0	10.41 a	7.49 b	7.86 b	8.59 A
	10	7.20 b	7.43 b	7.10 b	7.24 B
	20	8.38 b	8.17 b	8.05 b	8.20 AB
					Chitosan
Chitosan × Armurox	0	10.70 a	7.93 b	7.38 b	8.67 A
	10	7.27 b	7.68 b	8.20 b	7.72 B
	20	8.02 B	7.48 b	7.43 b	7.64 B
Armurox		8.66 A	7.70 B	7.67 B	

Table 9: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on Total yield per tree (kg) during 2019 growing season

HA (g tree^{-1})	**Chitosan (mg l^{-1})**	**Armurox (ml l^{-1})**			**HA x Chitosan**
		0	**2.5**	5	
0	0	17.32 f	31.62 de	34.35 b-e	27.76 c
	250	30.96 e	35.32 b-e	37.03 a-d	34.44 b
	500	34.54 b-e	36.88 b-d	37.07 a-d	36.16 ab
10	0	33.92 c-e	37.57 a-c	38.20 a-c	36.56 ab
	250	39.71 a-c	37.17 a-d	38.13 a-c	38.34 a
	500	35.19 b-e	36.87 b-d	39.42 a-c	37.16 ab
20	0	42.90 a	38.34 a-c	36.76 b-d	39.33 a
	250	40.14 ab	36.28 b-e	37.23 a-d	37.88 a
	500	38.01 a-c	36.16 b-e	39.34 a-c	37.84 a
					HA
HA× Armurox	0	27.61 d	34.61 c	36.15 bc	32.79 B
	10	36.27 bc	37.20 bc	38.58 ab	37.35 A
	20	40.35 a	36.93 bc	37.77 a-c	38.35 A
					Chitosan
Chitosan × Armurox	0	31.38 b	35.84 a	36.44 a	34.55 B
	10	36.94 a	36.26 a	37.46 a	36.89 A
	20	35.91 a	36.64 a	38.61 a	37.05 A
Armurox		34.74 B	36.25 AB	37.50 A	

Table 10: Effect of HA application and spraying with Chitosan and antitranspirant Armurox on No. of fruits per tree during 2019 growing season

HA (g tree^{-1})	Chitosan (mg l^{-1})	Armurox (ml l^{-1}) 0	2.5	5	HA x Chitosan
0	0	53.33 d	81.00 ab	87.17 a	73.83 c
	250	69.17 c	75.67 a-c	79.00 a-c	74.61b c
	500	79.00 ac	78.67 a-c	83.83 ab	80.50 a
10	0	74.50 bc	83.00 ab	82.50 ab	80.00 ab
	250	80.33 a-c	82.33 ab	82.67 ab	81.78 a
	500	75.67 a-c	83.33 ab	84.83 ab	81.25 a
20	0	86.50 a	83.50 ab	83.67 ab	84.56 a
	250	84.33 ab	84.17 ab	80.50 ab	83.00 a
	500	78.67 ac	82.50 ab	85.50 ab	82.22 a
					HA
HA× Armurox	0	67.17 c	78.44 ab	83.33 a	76.31 B
	10	76.83 b	82.89 a	83.33 a	81.02 A
	20	83.17 a	83.39 a	83.22 a	83.26 A
					Chitosan
Chitosan × Armurox	0	71.44 c	82.50 ab	84.44 a	79.46 A
	10	77.94 b	80.72 ab	80.72 ab	79.79 A
	20	77.78 b	81.50 ab	84.72 a	81.33 A
Armurox		75.72 B	81.57 A	83.29 A	

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