Egyptian J. Desert Res., **67**, No. 1, 171-185 (2017)

EFFECT OF NITROGEN FERTILIZATION AND ORGANIC ACIDS ON GRAINS PRODUCTIVITY AND BIOCHEMICAL CONTENTS OF QUINOA PLANT GROWN UNDER SOIL CONDITIONS OF RAS SADER-SINAI

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A field experiment was carried out at Ras Suder Research Station (located at 29º 32' 28" N and 32º 39' 25" E) throughout two seasons, i.e., 2014 and 2015 (saline soil of 8.56 dS m^{-1}, soil paste extract) and irrigated with water of 7.94 dS m^{-1} on quinoa (C*henopodium quinoa*, cv. Utosaya) using organic manure, mineral N-fertilization and foliar spry with humic and ascorbic acids. Growth, yield and nutrient uptake parameters increased with increasing N fertilizer, application of humic acid and spraying with ascorbic acid. Treatments with organic manure gave yield values greater than without manure by 9.0, 7.3, 8.9 and 9.4% for plant height, number of branches per plant, 1000-seed weight per plant and total seed yield. The combination of 48 mg organic manure ha^{-1} + 240 kg N ha^{-1} with spraying with humic acid solution of 600 mg L^{-1} + ascorbic acid solution of 1000 mg L^{-1} gave the highest positive response of plant height (cm) of 118, 26.4, 3.97 and 16.8 for plant height, number of branches per plant, 1000-seed weight, seed weight per plant and seed yield, respectively. The highest values were obtained for 1000-seed weight, yield and nutrient uptake. Treatments in relative comparison of the three highest treatment combinations are manure/148 kg N/ humic acid 300 mg L^{-1} /ascorbic acid 500 mg L^{-1} < manure/240 kg N/ humic acid 600 mg L^{-1} /ascorbic acid 1000 mg L^{-1}.

Keywords: N soil fertilizer, humic acid, ascorbic acid, organic manure, quinoa production, sandy loam soil, Ras Suder-Sinai

Salinity is a major problem in newly reclamation areas of Sinai, Egypt. According to water salinity classification of Hergert and Knudsen (2004), EC of < 0.75 dSm^{-1} has no detrimental effect on most crops and 0.75 to 1.50 dS m^{-1} has detrimental effects on sensitive crops, whereas 1.50 to 3.0 dS m^{-1} requires careful management and 3.0 to 7.5 dSm^{-1} is only for salt tolerant plants. Quinoa is generally recognized as one of the most saline tolerant crops known (Jacobsen, 2007). **S**ome of its cultivars can give high yields under high salinity level of as high as 12 dS m^{-1} (Pulvento et al., 2012).

Nutrients have several functions and affect quinoa yield parameters, the photosynthetic processes in leaves and plant growth are improved by N fertilization, it contributes greatly in protein synthesis, cell structure and carbohydrate production (Weisany et al., 2013). Oelke et al. (1992) noted that fertilization recommendations for quinoa are increased to 170-200 kg N ha^{-1} after more extensive research. Nitrogen exceeding these levels leads to lodging and delayed maturity. Razzaghi et al. (2011) reported that the soil N fertilizer is applied at 120 kg N ha^{-1}, nitrogen uptake by quinoa is 134 kg N ha^{-1} in sandy clay loam and 77 kg N ha^{-1} in sandy soil, leading to differing quinoa seeds yield of 3300 kg ha^{-1} and 2300 kg ha^{-1}, respectively. Gomaa (2013) reported that the application of nitrogen and phosphorus increased crude protein and nutrients content in quinoa seeds. Basra et al. (2014) stated that the soil application of N at 75 kg N/ha attained maximum economic harvest of quinoa. Geren (2015) reported that the soil application of N at 150 kg/ha to quinoa plant proved that N content raise quality of crude protein content (16%) and achieved maximum seeds yield (2.95 ton/ha). Darwinkel and Stølen (1997) reported the requirements of 70 kg P_2O_5 ha^{-1} for quinoa prior to seed filling and noted that existing levels of 29 kg phosphorus in many agricultural soils are likely sufficient. They also noted a fairly large requirement for potassium, with uptake of 400 kg K ha^{-1}, and recommend application of 100-200 kg K_2O ha^{-1}.

Application of humic substances to quinoa increases leaf water retention, photosynthetic activity and antioxidant metabolism under water stress conditions (Fahramand et al., 2014). Canellas and Olivares (2014) also stated that the humic substances increased roots density and absorption of nutrients across the plasma membranes of roots. El-Bassiouny et al. (2014) reported that application of humic acid to quinoa increased each of the followings: plant height, number of leaves, shoot growth and weights, photosynthetic pigment, soluble sugar, carbohydrates, amino acids and proline content, uptake of N, P, K, Ca, Mg and seed yield. Khaled and Fawy (2011) reported that foliar spray of humic substances increased the uptake of nutrients by maize grown under salt stress. Hamide et al. (2013) reported that humic and salicylic acid increased the germination percentage, radicle and seeds production of quinoa under salinity conditions.

Antioxidants such as antioxidant enzymes, ascorbic acid, carotenoids and flavonoids, protect plant against oxidative stress damages by scavenging reactive oxygen species through a defense mechanism protecting plant cells stress Gill and Tuteja (2010). Agatia et al. (2012) reported that flavonoids contribute to detoxification through chemically reactive oxygen species in plant cells. Brunetti et al. (2013) reported that flavonoids have potential to affect on nitrogen-activated protein kinases process to form protein in plants. Azarpour et al. (2014) stated that foliar application of ascorbic acid combined with application of N increased yield and nutrient contents in quinoa. Organic matter in forms of seed weed compost of 250 kg ha^{-1} increased yield by 6% whereas cattle manure of 2000 kg ha^{-1} increased quinoa 10% (Bilalis et al., 2012). On the other hand, Bilalis et al. (2014) reported that 2000 kg cow manure ha^{-1} by 100 kg N ha^{-1} fertilizer gave the highest protein yield of 2481 kg protein ha^{-1}. Lavini et al. (2014) stated that applying organic matter was more positive under deficit irrigation than under full irrigation at salinity up to 30 dS m^{-1}. The objective of this work is to assess the effect of N fertilization, ascorbic acid and humic acid on quinoa growth under high salinity conditions at Ras Suder region.

MATERIALS AND METHODS

A field experiment was carried out at Ras Sudr Research Station of the Desert Research Center, located at 29º 32' 28" N and 32º 39' 25" E on Quinoa (*Chenopodium quinoa,* a salinity resistant cv Utosaya) during two successive seasons, i.e. 2014 and 2015. The design was a factorial randomized complete block. Factors were organic manure application, as 0 and 48 mg ha^{-1}, N application as 148 and 240 kg N ha^{-1} and foliar spray of humic acid solution as no spray, 300 mg L^{-1} (Hu_1), and 600 mg L^{-1} (Hu_2), and spraying ascorbic acid solution as 500 mg L^{-1} (As_1) and 1000 mg L^{-1} (As_2), (Hu_1+ Asc_1) and (Hu_2+ As_2). Two extra treatments were conducted i.e. non-treated and manured non-N non-sprayed. Therefore, the total number of treatments was 28 treatment combinations (2 N x 2 manure x 7 spray) plus 2 extra treatments (30 treatments).

Foliar spray of both humic and ascorbic acid was done using 1400 L ha^{-1} and repeated for three times. The soil was saline (8.56 dS m^{-1}) of its paste extract and the irrigation water was saline (7.94 dS m^{-1}) (Table 1). Quinoa seeds were sown on the 30th November in rows; 50-cm apart and 15-cm between seed hills. Plant density was 13.3 plants m^{-2} (plant density of 134000 plant ha^{-1}). All treatments received 37 kg P ha^{-1} and 150 kg K ha^{-1} (P as ordinary superphosphate of 68 g P kg^{-1} and K as potassium sulphate of 420 g K kg^{-1}). Organic manure and P were applied during soil preparation, while the other fertilizers were applied as follows; the first and second dose of N and K fertilizers were added in September and October, respectively. While, the third dose was added during November and the fourth dose was added during December. Harvest stage at the end of February or the first half of March. The foliar application of humic acid and ascorbic acid were done at the same times of N and K soil applications, i.e., they were added through four times.

Table (1). Some chemical and physical properties of the studied soil.

Depth (cm)	pH	E.C (dS m^{-1})	OM	$CaCO_3$	Particle size distributes			C.E.C (emol kg^{-1})	Texture
					Sand	Silt	Clay		
			%			%			
0-30	7.73	8.56	2.28	26.9	81.20	8.57	10.23	5.81	L.S.
30-60	7.96	7.35	1.73	27.4	80.08	10.59	9.33	6.65	L.S.

Soluble cations and anions in soil (mmol L^{-1})

Depth (cm)	Na^+	K^+	Ca^{+2}	Mg^{+2}	HCO_3^-	Cl^-	SO_4^{2-}
0-30	47.1	8.9	24.4	5.2	8.1	51.3	26.2
30-60	41.2	12.7	15.8	3.8	3.5	46.5	23.5

Available nutrients in soil (mg kg^{-1})

Depth (cm)	N	P	K	Fe	Mn	Zn	Cu
0-30	36.8	5.19	48.5	4.26	2.18	1.25	0.57
30-60	21.5	3.84	52.3	4.64	2.23	1.31	0.66

E.C, pH, soluble cations and anions of irrigation water (mmol L^{-1})

	pH	EC	Na^+	K^+	Ca^{+2}	Mg^{+2}	HCO_3^-	Cl^-	SO_4^{2-}
	7.94	7.85	46.9	2.62	20.5	8.48	6.3	47.5	24.7

Seeds were cultivated in 30th November for two seasons. Soil analyses were done according to Page et al. (1984) and Klute (1986). Plant samples were analyzed for macro and micronutrients according to Cottenie et al. (1982). Measurements of total antioxidants and total phenols in soil and plant were done according to Rimmer (2009). Plant samples were collected at harvest. Plant height, number of branches per plant, the 1000-seed weight, and weight of seeds and straw per plant were determined. Also the yield of both straw and seeds per hectare was determined at the end of the experiment.

RESULTS AND DISCUSSION

1. Effect of N Mineral, Organic Manure and Organic Acids on Yield Quinoa Components

Data in table (2) show that the yield parameters of quinoa increased with increasing application of the N fertilizer, humic acid and ascorbic acid under conditions of Ras Suder soil during the two studied seasons.

Table (2). Effect of N fertilizer, organic manure and organic acids treatments applied on quinoa yields during the two studied seasons (2014 and 2015).

OM	N	Foliar Treatments	Plant height (cm)	Number branches	Weight of 1000 seeds (g)	Biological (g/plant)	Straw (g/plant)	Seeds (g/plant)	Biological (mg/ha)	Straw (mg/ha)	Seeds (mg/ha)
Without OM		Control	57	11.4	1.71	34.1	28.3	5.8	4.57	3.79	0.78
	N_1	Fol_0	68	17.5	2.63	50.2	43.5	6.7	6.73	5.83	0.9
	N_1	Hu_1	72	18.2	2.73	52.3	45.3	7	7.01	6.07	0.94
	N_1	Hu_2	76	18.9	2.85	57.2	49.5	7.7	7.66	6.63	1.03
	N_1	As_1	79	19.3	2.97	63.2	54.7	8.5	8.47	7.33	1.14
	N_1	As_2	82	19.7	3.04	66.5	57.6	8.9	8.91	7.72	1.19
	N_1	Hu_1+As_1	86	19.6	3.09	70.3	60.9	9.4	9.42	8.16	1.26
	N_1	Hu_2+As_2	90	20.3	3.12	72.9	63.1	9.8	9.77	8.46	1.31
	N_2	Fol_0	89	20.7	3.15	88.7	76.8	11.9	11.88	10.29	1.59
	N_2	Hu_1	94	21.5	3.22	91.8	79.5	12.3	12.3	10.65	1.65
	N_2	Hu_2	98	22.3	3.29	96.1	83.2	12.9	12.88	11.15	1.73
	N_2	As_1	102	22.8	3.35	98.5	85.3	13.2	13.2	11.43	1.77
	N_2	As_2	107	23.2	3.43	103.6	89.7	13.9	13.88	12.02	1.86
	N_2	Hu_1+As_1	111	23.1	3.49	106.8	92.5	14.3	14.32	12.4	1.92
	N_2	Hu_2+As_2	116	25.1	3.57	110	95.3	14.7	14.74	12.77	1.97
With OM		Control	65	12.8	1.97	42.85	36.7	6.15	5.74	4.92	0.82
	N_1	Fol_0	79	19.5	2.88	64.9	56.2	8.7	8.7	7.53	1.17
	N_1	Hu_1	83	19.9	2.95	70.9	61.4	9.5	9.5	8.23	1.27
	N_1	Hu_2	87	20.3	3.11	73.1	63.3	9.8	9.79	8.48	1.31
	N_1	As_1	92	20.8	3.19	75.9	65.7	10.2	10.17	8.8	1.37
	N_1	As_2	97	21.5	3.26	79.9	69.2	10.7	10.7	9.27	1.43
	N_1	Hu_1+As_1	101	21.9	3.32	85	73.6	11.4	11.39	9.86	1.53
	N_1	Hu_2+As_2	106	22.5	3.39	86.8	75.2	11.6	11.63	10.08	1.55
	N_2	Fol_0	95	22.1	3.47	105.5	91.4	14.1	14.14	12.25	1.89
	N_2	Hu_1	99	22.8	3.55	109.2	94.6	14.6	14.64	12.68	1.96
	N_2	Hu_2	103	23.3	3.63	112.9	97.8	15.1	15.13	13.11	2.02
	N_2	As_1	108	23.9	3.73	114.6	99.2	15.4	15.35	13.29	2.06
	N_2	As_2	112	24.4	3.81	119.7	103.7	16	16.04	13.9	2.14
	N_2	Hu_1+As_1	115	25.5	3.89	122.9	106.4	16.5	16.47	14.26	2.21
	N_2	Hu_2+As_2	118	26.4	3.97	125.3	108.5	16.8	16.79	14.54	2.25
		$LSD_{0.05}$ OM	2.58	0.46	0.087	4.47	3.87	0.6	0.289	0.25	0.039
		N	1.35	0.22	0.031	2.37	1.9	0.47	0.151	0.12	0.031
		Foliar Treat.	0.22	0.04	0.005	0.42	0.35	0.08	0.025	0.02	0.005
		OM x N	1.91	0.31	0.044	2.3	1.85	0.66	0.163	0.12	0.043
		OM x Fol. T	0.23	0.04	0.006	0.6	0.5	0.08	0.035	0.03	0.005
		N x Fol. T	0.38	0.07	0.009	0.73	0.61	0.14	0.049	0.04	0.009
		OM*N*Fol. T.	0.54	0.1	0.013	1.04	0.86	0.19	0.072	0.06	0.012

The yields and components of quinoa plants increased with increasing soil application of organic manure in comparison with those without application. The treatments with organic manure gave yield values greater than without application of organic treatments by 9.0, 7.3, 8.9 and 9.4% for plant height (cm), number of branches, weight of 1000-seed (g) and weight of seeds/plant (g), respectively, during the two studied seasons. This result is due to the important role of organic matter to improve plant growth and production by releasing available nutrients during the different stages of plant life, and improvement of physical and chemical soil properties. Finally, it decreases the adverse impact caused by soil salinity and irrigation water. These results agree with those obtained by Bilalis et al. (2012), Bilalis et al. (2014) and Lavini et al. (2014).

N fertilizer as soil application increased yield parameters of quinoa plant, the second rate of N fertilizer recorded the highest increase of yield components than control treatment, where these increases reached about 33, 43, 44 and 50% for plant height (cm), number of branches, weight of 1000-seed (g) and weight of seeds/plant (g), respectively. This result is due to that N has many functions in plant, this fact is described according to Weisany et al. (2013). The N effect on yield parameters of quinoa agrees with results obtained by Gomaa (2013), Basra et al. (2014) and Geren (2015).

The interactions between mineral N and organic amendments confirm that N fertilizer with ascorbic acid treatment (with or without OM) showed higher effect on yield components of quinoa than N fertilizer with humic acid treatment. This result may be due to that antioxidants have an important role to increase the ability of quinoa plant to resist salinity conditions and increase proline levels in the plant, which increases the plant ability to continue the natural growth under conditions of Ras Suder soils. Theses findings are according to Gill and Tuteja (2010), Hamid et al. (2010), Agatia et al. (2012) and Brunetti et al. (2013).

The effect of the foliar organic acids on quinoa yields was increased when spraying in addition to mineral fertilizers than spraying only, so that the results obtained assure that the combination between mineral N (238 kg ha^{-1}) + humic acid 600 mg L^{-1} + ascorbic acid 1000 mg L^{-1} with OM application was the most effective treatment on the yield parameters of quinoa plants, which achieved an increase reached about 118, 26.4, 3.97 and 16.8 for plant height (cm), number of branches, weight of 1000-seed (g) and weight of seeds/plant (g), respectively. Combining treatments between mineral N + organic amendments significantly increased quinoa yields as the following: N_2Hu_2+OM< N_2As_2+OM< $N_2Hu_2As_2$+OM. The above results agree with results obtained by Hamide et al. (2013), Azarpour et al. (2014) and Geren (2015).

2. Effect of Mineral N Fertilizer, Organic Manure and Organic Acids on Nutrients Content of Quinoa Straw and Seeds

Concerning the nutrients content in quinoa seeds during the two successive seasons, the second season took the same trend of the first season, so taking the average values of two seasons were taken for nutrients content and yield components to make the average account nutrients uptake by quinoa seeds during both seasons.

Data at table (3) show that the average values of N, P, and K contents of quinoa straw and seeds during the two studied seasons increased with increasing N and organic amendments rates. The N_2 treatment recorded increase of nutrient contents in straw by 24.6, 18.0 and 11.7% over the N_1 treatment for N, P and K, respectively, while being 29.0, 21.4 and 16.5% in seeds, respectively. Humic acid markedly increased K when comprised the other organic amendments, while ascorbic acid also markedly increased P. These facts may be due to that humic acid is source of K as potassium humate (12% K_2O), while antioxidants are involved in many biological processes within the plant, especially energy processes and increases the plant ability to resist the harmful effect caused by high salinity of soil and irrigation water. The previous facts are assured by the results obtained by El-Bassiouny et al. (2014) and Gill and Tuteja (2010). The superior treatment was N_2 Hu_2 As_2 with OM, which recorded the best nutrients content in straw and seeds of quinoa plants under condition of Ras Suder soil during the two studied seasons. The previous results agree with those obtained by Darwinkel and Stølen (1997), Khaled and Fawy (2011), Brunetti et al. (2013), Azarpour et al. (2014), El-Bassiouny et al. (2014) and Geren (2015).

3. Effect of Treatments on Nutrients Uptake by Quinoa Straw and Seeds of Quinoa

Concerning to the effect of integration between N mineral fertilizer and organic amendments on nutrients uptake by quinoa seeds (Table 4); the N, P and K uptake increased with increasing N applications. The N_2 treatment gave the highest increase than N_1 treatment by about 18.2, 38.1 and 35.7% for N, P and K, respectively. Humic acid application increased the nutrients uptake of seeds than control treatment by 11.5, 49.3 and 14.2% for N, P and K, respectively, while the increases due to spraying with ascorbic acids were 11.5, 49.3 and 14.2%, respectively. Application of organic matter increased nutrients uptake of quinoa seeds by 30.1, 26.1 and 44.2% for N, P, K, respectively over control (without OM).

Integration between N fertilizer and the studied organic amendments increased significantly the nutrients uptake of quinoa seeds. The most effective treatment was N_2+ Hu2 + As2 + OM . Quinoa straw N, P and K uptake were significantly affected by the different treatments. The highest values of N, P and K straw uptake were 389.7, 80 and 180.3 kg ha^{-1}, respectively, which obtained by N2+ Hu2+As2 with OM treatment. On the opposite, N1+ Fol_0 without OM gave the lowest values of N, P and K uptake by straw and were 96.2, 10.5 and 43.7 kg ha^{-1}, respectively. The previous results agree with those obtained by Khaled and Fawy (2011), Azarpour et al. (2014) and El-Bassiouny et al. (2014).

4. Effect of Mineral N Fertilizer and Organic Amendments on Some Biochemicals Content of Quinoa Plant

Data in table (5) show that the total phenol and total antioxidants activity in straw and seeds of quinoa increased with increasing application of N fertilizer, humic acid, ascorbic acid rates, especially when added with soil application of organic manure (48 mg ha^{-1}). Total phenol and total antioxidant activity in straw were higher than in seeds. Application of ascorbic acid showed the highest increase of total phenol and total antioxidants activity when compared with other studied factors. The most effective treatment was N soil fertilizer at 240 kg ha^{-1}, foliar ascorbic at the second rate of 1000 mg L^{-1} combined with humic acid at 600 mg L^{-1} and soil application OM. The above results agree with those obtained by Gill and Tuteja (2010), Hamide et al. (2013), Azarpour et al. (2014) and Lavini et al. (2014).

In conclusion, the yield parameters of quinoa increased with increasing application of N fertilizer, humic acid and ascorbic acid and addition of organic manure under conditions of Ras Suder soil during the two studied seasons. The yields and components of quinoa plants increased with soil application of organic manure in comparison with those without application. The treatments with organic manure gave yield values greater than without treatments by 9.0, 7.3, 8.9 and 9.4% for plant height (cm), number branches, weight of 1000-seed (g) and weight of seeds/plant (g), respectively, during the two studied seasons. The combination between mineral N at 240 kg ha^{-1} + humic acid at 600 mg L^{-1} + ascorbic acid at 1000 mg L^{-1} with OM application was the most effective treatment for yields, nutrients content and biochemicals content of quinoa plants, which achieved increase of about 118, 26.4, 3.97 and 16.8 for plant height (cm), number of branches, weight of 1000-seed (g) and weight of seeds/plant (g), respectively. Combining treatments of N fertilizer with organic amendments significantly increased yields, nutrient in straw or seeds or both of them in quinoa as the following: N_2Hu_2+OM< N_2As_2+OM< $N_2Hu_2As_2$+OM. Application of ascorbic acid showed the highest increase of total phenols and total antioxidants activity when compared with other studied factors.

Table (3). Effect of N fertilizer, organic manure and organic acids treatments on nutrient contents of quinoa straw and seeds.

OM	N	Foliar Treat.	Straw N%	Straw P%	Straw K%	Seeds N%	Seeds P%	Seeds K%
Without OM	Control		1.07	0.12	0.49	1.22	0.16	0.54
	N_1	Fol_0	1.65	0.18	0.75	1.86	0.21	0.85
	N_1	Hu_1	1.69	0.21	0.89	1.92	0.24	1.01
	N_1	Hu_2	1.74	0.23	0.93	1.99	0.26	1.06
	N_1	As_1	1.81	0.31	0.79	2.09	0.36	0.91
	N_1	As_2	1.85	0.36	0.81	2.16	0.42	0.94
	N_1	Hu_1+As_1	1.89	0.39	0.97	2.22	0.46	1.14
	N_1	Hu_2+As_2	1.95	0.43	1.01	2.31	0.51	1.20
	N_2	Fol_0	2.21	0.23	0.89	2.68	0.28	1.07
	N_2	Hu_1	2.26	0.25	1.05	2.75	0.30	1.27
	N_2	Hu_2	2.33	0.27	1.11	2.83	0.33	1.35
	N_2	As_1	2.41	0.37	0.89	2.93	0.44	1.08
	N_2	As_2	2.48	0.42	0.94	3.02	0.52	1.14
	N_2	Hu_1+As_1	2.53	0.46	1.14	3.08	0.56	1.39
	N_2	Hu_2+As_2	2.59	0.51	1.19	3.16	0.62	1.45
With OM	Control		1.15	0.17	0.63	1.34	0.20	0.74
	N_1	Fol_0	1.77	0.23	0.88	2.07	0.27	1.03
	N_1	Hu_1	1.78	0.25	0.95	2.09	0.29	1.12
	N_1	Hu_2	1.82	0.28	0.99	2.14	0.33	1.16
	N_1	As_1	1.85	0.37	0.86	2.18	0.44	1.01
	N_1	As_2	1.91	0.41	0.89	2.24	0.48	1.05
	N_1	Hu_1+As_1	1.95	0.44	1.05	2.30	0.52	1.24
	N_1	Hu_2+As_2	2.03	0.48	1.11	2.39	0.57	1.31
	N_2	Fol_0	2.32	0.27	0.96	2.85	0.33	1.18
	N_2	Hu_1	2.38	0.29	1.08	2.94	0.36	1.33
	N_2	Hu_2	2.43	0.31	1.12	3.00	0.38	1.38
	N_2	As_1	2.48	0.41	0.98	3.07	0.50	1.21
	N_2	As_2	2.55	0.46	1.03	3.16	0.57	1.27
	N_2	Hu_1+As_1	2.61	0.49	1.19	3.23	0.60	1.46
	N_2	Hu_2+As_2	2.68	0.55	1.24	3.32	0.68	1.52
$LSD_{0.05}$ OM			0.022	0.013	0.018	0.038	0.017	0.027
N			0.036	0.008	0.010	0.049	0.010	0.015
Foliar Treat.			0.007	0.003	0.004	0.009	0.004	0.005
OM x N			0.035	0.011	0.014	0.048	0.014	0.021
OM x Fol. T			0.009	0.004	0.004	0.013	0.004	0.005
N x Fol. T			0.011	0.006	0.007	0.016	0.007	0.009
OM*N*Fol. T.			0.016	0.008	0.010	0.023	0.010	0.012

Table (4). Effect of N fertilizer, organic manure and organic acids on nutrients uptake by quinoa straw and seeds.

OM	N	Foliar Treatment	Straw (kg/ha)			Seeds (kg/ha)		
			N	P	K	N	P	K
Without OM		Control	40.6	4.5	18.6	9.5	1.2	4.2
	N_1	Fol_0	96.2	10.5	43.7	16.7	1.9	7.7
	N_1	Hu_1	102.6	12.7	54.0	18.0	2.3	9.5
	N_1	Hu_2	115.4	15.2	61.7	20.5	2.7	10.9
	N_1	As_1	132.7	22.7	57.9	23.8	4.1	10.4
	N_1	As_2	142.8	27.8	62.5	25.7	5.0	11.2
	N_1	Hu_1+As_1	154.2	31.8	79.2	28.0	5.8	14.4
	N_1	Hu_2+As_2	165.0	36.4	85.4	30.3	6.7	15.7
	N_2	Fol_0	227.4	23.7	91.6	42.6	4.5	17.0
	N_2	Hu_1	240.7	26.6	111.8	45.4	5.0	21.0
	N_2	Hu_2	259.8	30.1	123.8	49.0	5.7	23.4
	N_2	As_1	275.5	42.3	101.7	51.9	7.8	19.1
	N_2	As_2	298.1	50.5	113.0	56.2	9.7	21.2
	N_2	Hu_1+As_1	313.7	57.0	141.4	59.1	10.8	26.7
	N_2	Hu_2+As_2	330.7	65.1	152.0	62.3	12.2	28.6
With OM		Control	56.6	8.4	31.0	11.0	1.6	6.1
	N_1	Fol_0	133.3	17.3	66.3	24.2	3.2	12.1
	N_1	Hu_1	146.5	20.6	78.2	26.5	3.7	14.2
	N_1	Hu_2	154.3	23.7	84.0	28.0	4.3	15.2
	N_1	As_1	162.8	32.6	75.7	29.9	6.0	13.8
	N_1	As_2	177.1	38.0	82.5	32.0	6.9	15.0
	N_1	Hu_1+As_1	192.3	43.4	103.5	35.2	8.0	19.0
	N_1	Hu_2+As_2	204.6	48.4	111.9	37.0	8.8	20.3
	N_2	Fol_0	284.2	33.1	117.6	53.9	6.2	22.3
	N_2	Hu_1	301.8	36.8	136.9	57.6	7.1	26.1
	N_2	Hu_2	318.6	40.6	146.8	60.6	7.7	27.9
	N_2	As_1	329.6	54.5	130.2	63.2	10.3	24.9
	N_2	As_2	354.5	63.9	143.2	67.6	12.2	27.2
	N_2	Hu_1+As_1	372.2	69.9	169.7	71.4	13.3	32.3
	N_2	Hu_2+As_2	389.7	80.0	180.3	74.7	15.3	34.2
$LSD_{0.05}$ OM			13.7	3.20	7.13	2.72	0.62	1.39
N			9.3	1.78	3.51	1.83	0.35	0.69
Foliar Treat.			1.7	0.35	0.82	0.34	0.07	0.16
OM x N			9.0	2.52	3.41	1.78	0.49	0.68
OM x Fol. T			2.4	0.37	0.87	0.49	0.07	0.17
N x Fol. T			3.0	0.60	1.42	0.60	0.11	0.28
OM*N*Fol. T.			4.2	0.86	2.01	0.84	0.16	0.39

Table (5). Effect of N fertilizer and organic amendments on some bio-chemicals component of quinoa plant.

OM	N	Foliar Treatment	Total antioxidants (µg Asc/ml)		Total phenols (µg Gal/ml)	
			Seeds	Straw	Seeds	Straw
Without OM		Control	30	43	68	108
	N_1	Fol_0	58	65	132	165
	N_1	Hu_1	63	74	145	185
	N_1	Hu_2	69	81	158	205
	N_1	As_1	116	127	264	317
	N_1	As_2	149	158	342	395
	N_1	Hu_1+As_1	136	147	312	367
	N_1	Hu_2+As_2	162	171	372	427
	N_2	Fol_0	64	77	147	193
	N_2	Hu_1	70	84	163	211
	N_2	Hu_2	75	89	175	225
	N_2	As_1	125	133	288	333
	N_2	As_2	153	167	350	416
	N_2	Hu_1+As_1	147	158	338	394
	N_2	Hu_2+As_2	175	188	400	471
With OM		Control	50	60	114	149
	N_1	Fol_0	72	85	163	213
	N_1	Hu_1	77	89	177	224
	N_1	Hu_2	85	97	192	245
	N_1	As_1	132	145	304	362
	N_1	As_2	179	187	411	466
	N_1	Hu_1+As_1	148	159	340	395
	N_1	Hu_2+As_2	188	193	431	482
	N_2	Fol_0	85	98	197	244
	N_2	Hu_1	92	104	211	262
	N_2	Hu_2	99	112	228	281
	N_2	As_1	146	159	333	397
	N_2	As_2	183	197	429	494
	N_2	Hu_1+As_1	157	168	363	421
	N_2	Hu_2+As_2	194	208	446	523
$LSD_{0.05}$ OM			15.4	3.2	23.7	27.4
N			10.5	1.6	17.0	20.2
Foliar Treat.			13.2	1.8	16.2	17.5
OM x N			14.8	2.3	34.8	41.4
OM x Fol. T			14.0	1.9	17.1	18.5
N x Fol. T			17.1	2.3	20.9	22.6
OM*N*Fol. T.			24.2	4.3	39.6	42.8

REFERENCES

Agatia, G., E. Azzarellob, S. Pollastri and M. Tattini (2012). Flavonoids as antioxidants in plants: location and functional significance. Plant Science, 196: 67–76.

Azarpour, E., H.R. Bozorgi and M. Moraditochaee (2014). Effects of ascorbic acid foliar spraying and nitrogen fertilizer management in spring cultivation of quinoa (*Chenopodium quinoa*) in north of Iran. Biological Forum, 6 (2): 254-260.

Basra, S.M.A., S. Iqbal and I. Afzal (2014). Evaluating the response of nitrogen application on growth, development and yield of quinoa genotypes. Int. J. Agric. Biol., 16 (5): 886-892.

Bilalis, D., I. Kakabouki, A. Karkanis, I. Travlos, V. Triantafyllidis and D. Hela (2012). Seed and saponin production of organic quinoa (*Chenopodium quinoa* Willd.) for different tillage and fertilization. Not Bot. Horti Agrobot. Cluj-Napoca, 40: 42–46.

Bilalis, D.I. Kakabouki, A. Karkanis, G. Zervas, E. Tsiplakou and D. Hela (2014). Effects of fertilization and tillage system on growth and crude protein content of quinoa (*Chenopodium quinoa* Willd.): An alternative forage crop. Emir. J. Food Agric., 26 (1): 18-24.

Brunetti, C., M.D. Ferdinando, A. Fini, S. Pollastri and M. Tattini (2013). Flavonoids as antioxidants and developmental regulators: relative significance in plants and humans. Int. J. Mol. Sci., 14: 3540-3555.

Canellas, L.P. and F.L. Olivares (2014). Physiological responses to humic substances as plant growth promoter. Canellas and Olivares Chemical and Biological Technologies in Agriculture, 1 (3): 1-11.

Cottenie, A., M. Verlso, L. Kilkens, G. Velghe and R. Camerlynck (1982). In "Chemical Analysis of Plants and Soils". Lab. Agroch. State Univ. Gent, Belgium.

Darwinkel, A. and O. Stølen (1997). Understanding the quinoa crop: Guidelines for growing in temperate regions of N.W. Europe. European Commission, Brussels.

El-Bassiouny, H.S.M., B.A. Bakry, A.A. Attia and M.M. Abd Allah (2014). Physiological role of humic acid and nicotinamide on improving plant growth, yield and mineral nutrient of wheat (*Triticum durum*) grown under newly reclaimed sandy soil. Agricultural Sciences, 5: 687-700.

Fahramand, M., H. Moradi, M. Noori, A. Sobhkhizi, M. Adibian, V. abdollahi and K. Rigi (2014). Influence of humic acid on increase yield of plants and soil properties. International Journal of Farming and Allied Sciences, 3 (3): 339-341.

Geren, H. (2015). Effects of different nitrogen levels on the grain yield and some yield components of quinoa (*Chenopodium quinoa* Willd.)

under mediterranean climatic conditions. Turkish Journal of Field Crops, 20 (1): 59-64.

Gill, S.S. and N. Tuteja (2010). Reactive oxygen species and antioxidant machinery in abiotic stress tolerance in crop plants. Plant Physiology and Biochemistry, 48: 909-930.

Gomaa, E.F. (2013). Effect of nitrogen, phosphorus and biofertilizers on quinoa plant. Journal of Applied Sciences Research, 9 (8): 5210-5222.

Hamid, A.A., O. O. Aiyelaagbe, L.A. Usman, O.M. Ameen and A. Lawal (2010). Antioxidants: its medicinal and pharmacological applications. African Journal of Pure and Applied Chemistry, 4 (8): 142-151.

Hamide, F., A. Atefe, M. Samane and A. Astaraee (2013). Influence of salicylic acid and humic acid on salinity stress tolerance during seed germination of (*Lens culinaris* medik). Journal of Current Research IN Science, 1 (5): 396-399.

Hergert, G.W. and D. Knudsen (2004). In “Irrigation Water Quality Criteria”. Institute of Agriculture and Natural Resources, Nebraska.

Jacobsen, S.E. (2007). In “Quinoa’s World Potential”. (Ochatt, S. and S.M. Jain Eds.). Breeding of Neglected and Under-utilized Crops, Spices and Herbs. Science Publishers, Enfield, p. 109–122.

Khaled, H. and H.A. Fawy (2011). Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil and Water Res., 6 (1): 21–29.

Klute, A.A (1986). In “Methods of Soil Analysis”. Part 1. Second Edition. Mahattanatawee, K., J.A. Manthey, G. Luzio, S.T. Talcott and K. Goodner. American Society of Agronomy Inc. Publishes, Madison, Wisconsin, USA.

Lavini, A., C. Pulvento, R. d’Andria, M. Riccardi, R. Choukr-Allah, O. Belhabib, A. Yazar, C. Incekaya, S. Metin Sezen, M. Qadir and S.E. Jacobsen (2014). Quinoa’s potential in the mediterranean region. J. Agro. Crop Sci., 200: 344–360.

Oelke, E.A., D.H. Putnam, T.M. Teynor and E.S. Oplinger (1992). In “Quinoa”. Alternative Field Crops Manual. University of Wisconsin Cooperative Extension Service, University of Minnesota Extension Service, Center for Alternative Plant and Animal Products.

Page, A.L., R.H. Miller and D.R. Keeney (1984). In “Methods of Soil Analysis”. Part 2: Chemical and Microbiological Properties. Second Edition. Am. Soc. Agron. Inc., Soil Sci. Soc. Am. Inc. Pub. Madison, Wisconsin, USA.

Pulvento, C., M. Riccardi, A. Lavini, G. Iafelice, E. Marconi, and R. d’ Andria (2012). Yield and quality characteristics of quinoa grown in open field under different saline and non-saline irrigation regimes. J. Agron. Crop Sci., 198: 254–263.

Razzaghi, F., S.H. Ahmadi, C.R. Jensen, S.E. Jacobsen and M.N. Andersen (2011). The salt tolerance of quinoa measured under field conditions. International Commission on Irrigation and Drainage, p. 149-153.

Rimmer, S. (2009). Antioxidants in soil organic matter and in associated plant materials. European Journal of Soil Science, 60 (2): 170-175.

Weisany, W., Y. Raei and K.H. Allahverdipoor (2013). Role of some of mineral nutrients in biological nitrogen fixation. Bull. Env. Pharmacol. Life Sci., 2 (4): 77-84.

تأثير التسميد النتروجيني والأحماض العضوية على إنتاجية الحبوب والمحتوى البيوكيميائي لنبات الكينوا النامي تحت ظروف أراضي رأس سدر– سيناء

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أقيمت دراسة حقلية لنباتات الكينوا بمحطة بحوث رأس سدر التابعة لمركز بحوث الصحراء والواقعة عند الإحداثيات 32º 39' 25" E & 29º 32' 28" N خلال موسمين متتاليين؛ ٢٠١٤ و٢٠١٥. هذه التربة تروى بمياة ذات ملوحة ٧,٩٤ ديسمنز/سم. بينما كانت ملوحة EC التربة (مستخلص عجينة التربة) ٨,٥٦ ديسمنز/سم. بذورالكينوا صنف يوتوسايا (صنف مقاوم للملوحة) زرعت في ٣٠ نوفمبر على بعد ١٥سم بين البذور و٥٠ سم بين الصفوف. كان متوسط كثافة النباتات ١٣,٣ نبات/م^{٢} أو ١٣٣٠٠٠ نبات في الهكتار. الهدف من هذه الدراسة هو إحراز أقصى محصول بإستخدام التسميد المعدني بخاصة النتروجين والتسميد العضوي للوصول إلى حدود الكفاية من العناصر الغذائية لنبات الكينوا وحامض الهيومك للمساعدة في نمو النبات وكذلك حامض الأسكوربيك لزيادة قدرة النبات على مقاومة الظروف الملحية فى أراضي رأس سدر علاوة على أهمية السماد العضوي لتقليل الأثر الضار للملوحة وتحسين خواص التربة.

النتائج المتحصل عليها تؤكد أن قياسات المحصول لنبات الكينوا ومحتوى العناصر الغذائية والممتص منها تزداد مع زيادة معدلات إضافة سماد النتروجين المعدني، السماد العضوي، حمض الهيومك وحمض الأسكوربيك تحت ظروف أراضي رأس سدر خلال موسمي الدراسة. قياسات المحصول لنبات الكينوا تزداد مع إضافة السماد العضوي عند المقارنة بعدم الإضافة. المعاملات المضاف إليها السماد العضوي أعطت قيم للمحصول أكبر من المعاملات بدون إضافة، وكانت الزيادة حوالس ٩,٠، ٧,٣، ٨,٩ و٩,٤ لكل من إرتفاع النبات (سم)، عدد الأفرع، وزن ألف بذرة (جرام) ووزن البذور/نبات (جرام)، على التوالي خلال الموسمين المتتاليين. التداخل بين التسميد النتروجيني ٢٤٠ كجم/هكتار + ٦٠٠ ملليجرام/لترحامض الهيومك +١٠٠٠ ملليجرام/لتر حامض الأسكوربيك مع إضافة المادة العضوية تكون هي المعاملة الأكثر تأثيرًا على المحصول (البذور والقش) ومحتوى العناصر الغذائية والمحتوى البيوكميائي لنبات الكينوا. حيث حققت زيادة المحصول النتائج ١١٨، ٢٦,٤، ٣,٩٧ و٤٧,٤ لكل من إرتفاع النبات (سم)، عدد الأفرع، وزن ألف بذرة (جرام) ووزن البذور/ نبات (جرام)، على التوالي. تأثيرالتداخل بين المعاملات على المحصول ومحتوى العناصر الغذائية الممتص منها والمحتوى البيوكيميائي لنبات الكينوا قد ترتبت كالآتي: N_2Hu_2+OM< N_2As_2+OM< $N_2Hu_2As_2$+OM. إضافة حامض الأسكوربيك كان الأعلى في زيادة الفينولات الكلية ومضادات الأكسدة الكلية النشطة عند مقارنتها مع عوامل الدراسة الأخرى.