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Improving the Productivity of Some Varieties of Lentil Growing under Salt Stress

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim was to study the interaction and effect of gibberellic acid (200 ppm) between indole acetic acid (100 ppm) in order to follow their effect on the productivity of 5 lentil varieties (Sinai 1, Giza 9, Giza 370, Giza 4 and Giza51) known to be affected by salt stress in Sinai.
Study Design: The experiment was conducted as split plot design having varieties in main plot and IAA and GA3 in subplot.
Place and Duration of Study: The place of Research was "Production Station, Maghara at North of Sinai government, that follow Desert research center, of the ministry of agriculture, Egypt during the two successive seasons (2014/2015 and 2015 / 2016, respectively). The duration of the study was between June 2009 and July 2010 at Medicine (Medical Unit IV) and Department of Radiology. Services of Institute of Medical Sciences (SIMS) and Hospital Lahore.
Methodology: The soil was prepared. The Seeds covered with a thin layer of soil, sown and watered. Three weeks later, the developed plants were thinned. Finally, the plants collected after 110 days of growth. Growth, yield and chemical contents determined.
Results: The results showed that application of IAA+GA_3 substantially improved plant growth for all

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verities of lentil. Giza51 under treatment of IAA + GA_3 give the highest value of plant height and dry weight of the plant. Giza4 variety with IAA+GA_3 surpassed another verity of primary branches/plant. Whereas Sinai1variety with IAA+GA_3 treatment surpassed in number of pods/plant, however, Giza370 surpassed in secondary branches/plant compared with other varieties and treatments. The hormones IAA and GA_3 were applied individually as well as in combination (IAA+GA_3) showed a significant increase in plant height, number of branches/plant of verity Sinai1, number of seeds/plant, number of pods/plant of verity Giza 370 and biological yield ton/ha of verity Giza 4.
Conclusion: The concentration of GA_3 (200 ppm) is increase grain yield of variety Giza 4 and seed yield/plant of variety Giza 51. The combined dose of GA_3+IAA showed a significant increase in all chemical and minerals contents in seed cultivar of Sinai 1 compared with other varieties.

Keywords: Salt stress; improving productivity; lintel varieties; GA_3 ad IAA; Sinai.

1. INTRODUCTION

Lentil is a valuable crop for humanity for its higher protein content (20.2 g /100g dried seed) which comparable with faba bean and higher than chickpeas, and more than double of wheat. It has also a high concentration of folic acid, fibre (4g/100g dried seed) and iron. In addition to these, it is beneficial for its low calorie (340 cal/100g dried seed), fat (0.6 g/100g dried seed) and cholesterol content. It has a remarkable vitamin and mineral value with 68 mg Ca, 325 mg P, 7.0 mg Fe, 29 mg Na, 780 mg K, 0.46 mg thiamine, 0.33 mg riboflavin and1.3 mg niacin [1-3]. Besides its nutritive value, it has an agricultural value of nitrogen fixation. Salinity is the main environmental factor accountable for decreasing crop productivity in many areas of the world especially in arid and semi-arid regions [4]. Salinity reduces growth and yield to the roots due to the osmotic effect of external salt and by toxic effects of accumulation within the plant [5]. These factors manifest themselves by morphological, physiological and metabolic modifications in plant such as a decrease in seed germination, a decrease in shoot and root length [6], alterations in the integrity of cell membranes, changes in different enzymatic activities and photosynthesis [6,7].

Plant Growth Regulators (PGRs) are the chemicals which influence the plant growth when they are applied in very little quantities. It is known that the developmental processes in plants are regulated by the action and balance of the different groups of growth regulators which may act as promoters or inhibitors of these processes [8] showed that spraying Acanthus mollis plant with GA3 enhanced vegetative growth measurements.GA3 also increased mobilisation of starch in cotyledons by increasing amylase activity. Plant growth regulators (IAA and GA3) induced a marked accumulation of protein content and carbohydrates content [9,10]. Indol-3-acetic acid also increased growth and yield of black seeds as found by Hussain et al. [11].

In our study, we used IAA and GA_3 to follow their effect on the productivity of 5 lentil varieties known to be affected by salt stress in Sinai.

2. MATERIALS AND METHODS

2.1 Plant and Treatments

Two field experiments were carried out at the Research and Production Station, Maghara at North of Sinai government that follow Desert research center, ministry of agriculture, Egypt during the two successive seasons 2014/2015 and 2015/2016, respectively, to study the effect of gibberellic acid (200 ppm) and indole acetic acid (100ppm) and interaction between them on growth and yield production of five varieties (Sinai 1, Giza 9, Giza 370, Giza 4 and Giza51) of lentil under condition of Sinai.

Physical and chemical properties of the soil analysis were according to Jackson [12] in Table 1.

2.2 Experimental Device

The soil was well prepared and added at the rate of 8 kg/m^2 as well as calcium super phosphate (15.5% P_2O_5) at the rate of 360 kg/ha during the preparation of the soil. Seeds were sown in lines apart and the distance between every row 60 cm and covered with a thin layer of the soil, then watered. Three weeks later, the developed plants were thinned.

2.2.1 Determination of growth/ yield parameters

The plants were collected after 110 days from sowing to determine the growth and yield characters: plant height (cm), dry weight/plant(g),

primary branches/plant, Secondary branches/plant, number of pods/plant, seed yield/plant (g), 1000 weight of seeds (g), straw yield (ton/ha), seeds yield (ton/ha) and biological yield (ton/ha).

Table 1. Physical and chemical properties of the soil

Character	2014/2015	2015/2016
Fine sand (%)	94.8	72.4
Silt (%)	4.5	2
Clay (%)	0.7	3.28
Texture	Sandy	Sandy
Organic matter (%)	0.93	0.85
pH	7.9	8
EC (mmhos/cm2)	1.3	2.4
CaCo3	3.8	2.86
Total N (ppm)	4.1	5.6
Available P (ppm)	4.3	4.7
K (mg/100 g soil)	5.6	4.55
Fe (ppm)	1.3	1.43
Zn (ppm)	0.35	0.5
Mn (ppm)	1.2	1.3

2.2.2 Determination of biochemical parameters

Photosynthetic pigments were determined according to Moran [13]. The superoxide dismutase (SOD) activity was assayed by the inhibition of the photochemical reduction of b-nitroblue tetrazolium chloride (NBT) according to Giannopolitis and Ries [14]. The CAT activity was assayed by monitoring the disappearance of hydrogen peroxide (H_2O_2) according to Polle et al. [15]. The POD activity was determined based on guaiacol oxidation measured at 470 nm according to Aebi [16]. Proline accumulation was determined as described by Bates et al. [17]. Determination of total carbohydrates was determined spectrophotometrically (as glucose) after acid hydrolysis using phenol sulphuric acid reagent [18]. Total Nitrogen content determined using Micro-Kjeldahl method [12]. Protein content was determined by the Kjeldahl method for the calculation of all proteins which equal nitrogen content multiplied by 6.25, A.O.A.C. [19].

2.2.3 Determination of mineral composition

Potassium content was extracted according to Chaudhary et al. [20]. Phosphorous content using chlorostannous reduced molybdo-phosphoric acid blue color method, in hydrochloric described system as described by Jackson [12]. Zinc Zn m/kg, copper Cu m/kg and iron Fe m/kg assay by atomic absorption.

2.3 Statistical Analysis

The experiment was conducted as split plot design having varieties in main plot and IAA, GA3 sub plot. Statistical analyses and mean comparisons were conducted using MSTATC software [21].

3. RESULTS AND DISCUSSION

3.1 Growth Analysis and Growth Attributes

The interaction effect of gibberellic acid, indole acetic acid and cultivars of lentil data in Table (2) show that Sinai-1 cultivar increase the plant height (cm) were obtained by using GA3 (200 ppm) (10.4%) compared with control but application of mixed doses (100 ppm IAA+200 ppm GA_3) increase (1.3%). Showed as increases in dry weight/plant(g) (13.7%), primary branches/plant (41.1%), secondary branches /plant (55.7%) and number of pods/plant (38.3%) compared with control, Giza-9 cultivar increases in growth characters were obtained by using application of mixed doses (100ppm IAA +200ppmGA_3) plant height (cm) (23.1%), dry weight/plant (g) (32.1%), primary branches/plant (49.9%), secondary branches/plant (62.7%) and number of pods/plant (18.2%) compared with control. Giza-370 give the highest values for all studied characters in growth by using application mixed doses (100ppm IAA+200ppm GA_3) and increases plant height (cm) (30.9%), dry weight/plant (g) (22.1%), primary branches/plant (31.9%), secondary branches/plant (67.3%) and number of pods/plant(24.6%) compared with control and also cultivars Giza-4 and Giza-51 give the highest values for all studied characters in growth by using application mixed doses (100ppm IAA + 200ppm GA_3) increasing plant height (22.8%, 15.6%), dry weight /plant (g) (20.1%, 7.1%), primary branches/plant (39.6%,58.8%), secondary branches/plant (45.5%, 52.3%) and number of pods/plant (42.1%, 24.1%). Plant hormones exert for reaching on plant growth, the precise action depending on the concentrations of the substances present and the sensitivity of the organ concerned. Applied GA_3 and IAA showed increase in growth characters similar results were observed by Afifi et al. [22, 23] where they fawned that application of GA_3 showed

remarkable increase in the number of compound leaves, GA_3 and IAA had regulatory effect to enhance the plant height, number of branches, number of leaves as compared to other plant growth regulators and control [24]. [25] concluded that IAA is successful in enhancing the plant growth and yield of barley cultivars and alleviated the adverse effect of water stress. GA_3 and IAA treated plants exhibited a higher value of dry weight [10,26]. Enhanced germination and seedling growth by plant growth regulators may be mediated through changes in the activities of carbohydrate metabolism enzymes [27].

3.2 Yield and its Components

Results in Table (3) clearly showed that application of mixed doses of (100ppm IAA + 200ppm GA_3) substantially improved and significant increases most yield component cultivar Sinai-1 give the highest values of plant height (29 cm) and number of branches /plant (2.8), Giza-370 surpassed in number of seeds /plant (41.6) and number of pods/plant (36.2), whereas, Giza-4 give the high value in biological yield (3.44 ton/ha). While treatment GA_3 (200ppm) gave the highest values in grain yield (2.98 ton/ha) in cultivar Giza-4 and seed yield /plant (1.59 g) in cultivar Giza-51. Gibberellin is majorly involved in the regulation of cell division in meristematic tissues, which results in the formation of new cells [28], and IAA is involved in mitotic activity in sub-apical tissues, resulting in increased plant growth [29]. The present study clearly demonstrated that growth hormones, whether alone or in combination, have a major impact in the stimulation of various growth parameters in lentil. It was concluded that plant growth hormones could be successfully employed for enhancement of seed yield, directly or indirectly, through its components.

C- Grain quality and chemical compositions:

Data presented in Tables (4) indicated that Sinai-1cultivar with application of mixed doses of (100ppm IAA + 200ppm GA_3) surpassed for all cultivars in all chemical compositions in chlorophyll a (4.23), chlorophyll b (1.39), carotenoids (0.94), superoxidase dismutase SOD (496.89), catalase CAT (23.27), peroxidase dismutase POD (3319.36), proline (144.71) and carbohydrate (1.608), whereas Giza-9 and (100ppm IAA) give the high value of phenol (1.0774). Our results revealed that IAA and GA_3 induced a marked accumulation of protein

Table 2. Interaction effect of gibberellic acid and indole acetic acid on some growth parameters of lentil cultivars under salinity condition

Treatments		Primary branches/ plant	Secondary branches/plant
Sinai-1	Control	2.934	2.086
	IAA 100	3.324	2.964
	GA_3 200	3.714	3.841
	IAA + GA_3	4.982	4.719
Giza-9	Control	2.642	1.794
	IAA 100	3.519	2.769
	GA_3 200	4.007	3.256
	IAA + GA_3	5.274	4.816
Giza-370	Control	3.324	1.989
	IAA 100	3.812	3.256
	GA_3 200	4.202	4.231
	IAA + GA_3	4.884	6.084
Giza-4	Control	3.422	2.184
	IAA 100	4.202	2.866
	GA_3 200	4.884	3.549
	IAA + GA_3	5.664	4.01
Giza-51	Control	2.252	2.574
	IAA 100	2.837	2.964
	GA_3 200	3.617	3.939
	IAA + GA_3	5.469	5.401
LSD V		1.8	2.7
LSD D		1.12	1.5
LSD V x D		0.8	0.9

Table 3. Interaction effect of gibberellic acid and indole acetic acid on some yield parameters of lentil cultivars under salinity condition along with plant morphological features

Treatments		plant height (cm)	number of branches/plant	Number of pods / plant	Number of seeds/ plant	Seed yield / plant	Grain yield (ton/ha)	Biological Yield (ton/ha)
Sinai-1	Control	22	2.5	14.7	23.2	0.693	1.417	1.651
	IAA 100	24	1.8	20.1	25.9	0.998	1.8519	2.17
	GA_3 200	25	1.9	24.9	29.2	1.212	1.4381	2.919
	IAA + GA_3	29	2.8	31.2	36.7	1.436	1.8457	3.29
Giza-9	Control	21	2.1	21.2	29.9	1.173	1.9282	2.514
	IAA 100	23	2.3	19.8	24.7	0.931	1.8159	2.023
	GA_3 200	25	2.5	29.8	31.7	1.579	1.6691	3.409
	IAA + GA_3	27	1.9	18.2	24.8	1.009	2.165	2.677
Giza-370	Control	20	2.0	18.4	23.3	0.747	1.5771	1.853
	IAA 100	23	1.5	20.3	24.8	1.096	2.7694	2.855
	GA_3 200	25	2.1	31.5	35.7	1.396	1.8695	3.114
	IAA + GA_3	27	2.5	36.2	41.6	1.234	1.914	3.359
Giza-4	Control	22	2.0	18.4	22.4	1.062	1.9444	2.611
	IAA 100	24	2.2	20.3	23.5	1.046	1.8531	3.197
	GA_3 200	25	1.8	28.9	34.5	1.563	2.9898	3.319
	IAA + GA_3	28	1.7	34.2	40.2	1.47	1.6747	3.442
Giza-51	Control	19	1.8	10.2	13.4	0.5	1.272	1.378
	IAA 100	23	1.8	23.2	30.7	0.874	1.7768	1.97
	GA_3 200	24	1.9	29.8	38.6	1.594	1.5074	3.155
	IAA + GA_3	26	2.2	20.7	26.9	0.87	2.1225	2.44
LSD V		5.51	0.75	3.4	4.5	0.21	1.12	0.5
LSD D		4.21	0.32	2.3	3.8	0.05	0.31	0.1
LSD V x D		1.58	0.08	1.2	1.9	0.012	0.06	0.03

Table 4. Interaction effect of gibberellic acid and indole acetic acid on some chemical contents of lentil cultivars under salinity condition

Treatments		Photosynthetic pigments mg/g			Antioxidant ug/g			Proline	Carbohydrate	Phenol
		Chlo. A	Chlo. B	Carot.	sod	Cat	pox	umole/g	g/100gm d.w.	
Sinai- 1	Control	3.4478	1.1091	0.8460	426.05	16.192	2853.84	101.79	1.2874	0.6421
	IAA 100	3.5541	1.1212	0.8541	457.42	20.241	3116.96	112.77	1.3982	1.0845
	GA_3 200	3.9943	1.3085	0.8976	473.61	21.252	3208.04	127.74	1.4961	0.7241
	IAA + GA_3	4.2352	1.3925	0.9401	496.89	23.276	3319.36	144.71	1.6083	0.9852
Giza-9	Control	3.4409	1.1069	0.8443	419.73	15.952	2811.54	100.47	1.2802	0.6381
	IAA 100	3.5470	1.1190	0.8524	450.64	19.941	3070.76	111.30	1.3896	1.0774
	GA_3 200	3.9863	1.3058	0.8958	466.59	20.937	3160.49	126.08	1.4890	0.7196
	IAA + GA_3	4.2267	1.3897	0.9382	489.52	22.931	3270.16	141.96	1.5983	0.9790
Giza-370	Control	3.4375	1.1058	0.8434	418.47	15.904	2803.08	98.563	1.2764	0.6362
	IAA 100	3.5434	1.1179	0.8515	449.28	19.881	3061.52	109.19	1.3854	1.0742
	GA_3 200	3.9823	1.3045	0.8949	465.19	20.874	3150.98	123.68	1.4845	0.7174
	IAA + GA_3	4.2225	1.3883	0.9373	488.05	22.862	3260.32	139.26	1.5935	0.9761
Giza-4	Control	3.4306	1.1036	0.8418	417.21	15.856	2794.67	96.690	1.2687	0.6324
	IAA 100	3.5363	1.1156	0.8498	447.94	19.820	3052.33	107.11	1.3771	1.0677
	GA_3 200	3.9744	1.3019	0.8931	463.79	20.811	3141.52	121.33	1.4756	0.7131
	IAA + GA_3	4.2014	1.3855	0.9354	486.58	22.793	3250.53	136.61	1.5839	0.9702
Giza-51	Control	3.4135	1.0980	0.8375	415.54	15.792	2783.49	97.972	1.2776	0.6368
	IAA 100	3.5187	1.1101	0.8456	446.14	19.741	3040.12	108.53	1.3868	1.0753
	GA_3 200	3.9545	1.2954	0.8886	461.94	20.728	3128.96	122.94	1.4860	0.7182
	IAA + GA_3	4.1803	1.3786	0.9307	484.64	22.702	3237.53	138.42	1.5951	0.9771
LSD V		7.41	0.331	0.0028	82.77	2.4	543.8	43.76	0.042	0.0023
LSD D		4.52	0.217	0.0015	71.75	1.2	453.2	35.76	0.013	0.0015
LSD V x D		2.11	0.029	0.0008	60.39	Ns	376.u	23.54	0.003	0.0011

Table 5. Interaction effect of gibberellic acid and indole acetic acid on some minerals contents of lentil cultivars under salinity condition

Treatments		Protein %	Nitrogen g/kg	Potassium g/kg	Phosphors g/kg	Zn m/kg	Cu m/kg	Fe m/kg	Mn m/kg
Sinai -1	Control	20.24	3.239	4.458	3.663	40.19	8.835	44.35	40.06
	IAA 100	21.61	3.458	4.668	4.010	41.19	9.484	46.52	42.99
	GA_3 200	22.86	3.658	4.832	4.228	42.73	9.731	47.92	45.33
	IAA + GA_3	24.29	3.886	4.987	4.365	43.93	10.27	49.20	46.64
Giza-9	Control	19.73	3.157	4.404	3.599	40.10	8.771	44.20	40.00
	IAA 100	20.98	3.357	4.613	3.946	41.01	9.247	46.37	42.79
	GA_3 200	22.18	3.549	4.768	4.073	41.49	9.539	46.76	44.39
	IAA + GA_3	23.66	3.786	4.933	4.301	42.74	9.886	48.76	46.10
Giza-370	Control	19.33	3.093	4.321	3.554	39.82	8.707	44.14	39.77
	IAA 100	20.30	3.248	4.577	3.882	40.83	9.109	46.19	45.14
	GA_3 200	21.55	3.449	4.714	3.927	41.40	9.293	46.83	45.21
	IAA + GA_3	22.75	3.640	4.942	4.228	42.47	9.676	48.65	46.00
Giza-4	Control	19.96	3.193	4.440	3.645	40.10	8.808	44.14	39.04
	IAA 100	21.44	3.430	4.650	3.991	41.10	9.457	46.30	41.97
	GA_3 200	22.12	3.540	4.805	4.064	42.31	9.685	46.58	43.49
	IAA + GA_3	24.00	3.841	4.978	4.347	43.83	10.25	48.98	45.62
Giza-51	Control	19.44	3.111	4.385	3.581	40.00	8.744	43.99	38.97
	IAA 100	20.70	3.312	4.595	3.927	40.92	9.220	46.15	41.76
	GA_3 200	21.21	3.394	4.686	4.064	41.04	9.484	46.76	42.57
	IAA + GA_3	23.38	3.741	4.914	4.283	43.11	9.858	48.55	45.08
LSD V		7.276	0.402	0.18	0.611	6.77	2.901	4.733	8.132
LSD D		6.416	0.712	0.217	0.711	2.62	3.011	7.833	9.532
LSD V x D		5.096	0.193	0.107	0.211	1.49	0.971	1.673	1.232

content and carbohydrates content. This accumulation of carbohydrates due to GA3 and IAA treatment might be linked with the efficiency of photosynthetic apparatus, which leads to an increase in plant productivity and dry matter production [30]. Increasing protein content by plant growth regulators may be due to enhancing the formation of rough endoplasmic reticulum that provides the appropriate medium for increasing polyribosome and RNA [31,32].

3.3 Grain Quality and Mineral Composi-tions

Table (5) clearly showed that Sinai-1cultivar with application of mixed doses of (100ppm IAA + 200 ppm GA_3) surpassed for all cultivars in all mineral composition and give the highest values of protein (24.29%), potassium (4.987g/kg) phosphors (4.365g/kg), Zn (43.93m/kg), Cu (10.27m/kg), Fe (49.20m/kg) and Mn (46.64m/kg) whereas Giza-4 give the highest value of nitrogen (3.841g/kg). GA_3 and IAA stimulated a considerable increase in mineral contents of lentil plant but markedly decreased phenolic compounds. The increasing of seed germination percentage as a result of the exogenous application of both growth regulators was positively correlated with the decrease in total phenols. The result agrees with El-Araby et al. [33].

4. CONCLUSION

The present study clearly demonstrated that growth hormones, whether alone or in combination, have a major impact in the stimulation of various growth parameters in lentil. It was concluded that plant growth hormones could be successfully employed for enhancement of seed yield, directly or indirectly, through its components. Increasing protein content by plant growth regulators may be due to an increase in the formation of rough endoplasmic reticulum that provides the appropriate medium for increasing polyribosome and RNA. The increasing of seed germination percentage as a result of the exogenous application of both growth regulators was positively correlated with the decrease in total phenols. The salt stress has a significant impact on the productivity of leguminous crops, especially lentils. The treatment of growing plants under the influence of Sinai salinity with gibberellic acid GA_3 and indole acetic acid IAA used as growth regulators induces the accumulation of substances such as antioxidants and photosynthesis products which reduces the effect of salinity, especially with Sinai 1 variety.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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