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Response of hot pepper (*Capsicum annum* L.) to nitrogen fertilizer and humic acid levels under sandy soil conditions in plastic house.

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ABSTRACT

The present research was carried out during the two successive seasons of 2010/2011 and 2011/2012 at the Experimental Station of National Research Centre at Nubaria region, North Egypt to evaluate response of hot pepper (*Capsicum annum* L.) cv Beni-Sweif growth, yield and fruit quality to nitrogen fertilizer at rates of 25, 50 and 100 Kg/ fed., as well as humic acid at rate of 0, 1g/L and 2gL. The results showed that, hot pepper plants which received 100 Kg of nitrogen with 2 g/L of humic acid resulted highest vegetative growth characteristics i.e. plant height, stem number and leaf chlorophyll content and reproductive factors expressed as fruits number and weight per plant as well as total yield / m^2 as well as N%, protein % and VC (mg/100g F.W) values in two seasons.

Key words: hot pepper, nitrogen, humic acid, levels, growth, yield, fruit quality.

Introduction

Hot pepper (*Capsicum annum* L.) is an important agronomic crop which rich in antioxidants, vitamin C, pro-vitamin A, E, P, B_1 (thiamine), B_2 (riboflavin) and B_3 (niacin) and good source of potassium, phosphorus and calcium, is known as a vegetable, and consumed both as fresh and dehydrated spices Bosland and Vostava, (2000). Moreover, it is one of the valuable medicinal plants in pharmaceutical industries because of high amounts of antioxidant and capsaicin as main active substances Navarro *et al* (2006).

The productivity of hot pepper is highly responsive to N fertilizer Tumbare and Niikam (2004) reported that nitrogen fertilizer increased fruit weight, yield and fruit number of chili peppers. Madeira and de Varennes (2005) observed that total chlorophyll content, leaf N concentration and shoot dry weight of pepper increased with increasing N fertilization. Guohua *et al* (2001) found that varying nitrogen form affected on sweet pepper flowering, fruit set, fruit ripening time and yield. Qawasmi *et al* (1999) reported that increasing the rates of nitrogen applied in pepper plants increases the uptake of nitrogen by the plants and at the same time, stimulated the uptake of potassium and phosphorus through the effect of nitrogen on them. However, N sources may affect plant growth via many processes within the soil plant system and inside the plant Wiesler (1997) and Ghoname *et al* (2009) on hot pepper plants**.** On the same respect, Aminifard *et al* (2012) results showed that, nitrogen fertilizer was significantly affected on hot pepper vegetative growth characteristics (plant height, stem number and leaf chlorophyll content) and reproductive factors (fruits number and weight per plant as well as plant yield). It was observed that fertilization with 50 kg N/ha resulted to the highest fruit weight and plant yield.

Humic acid can be applied directly to the plant foliage in liquid form. It is one of the major components of humus. Natural organic substances, humic acid were most of known trace minerals necessary to the development of plant life Senn (1991). Foliar application of humic acid consistently enhanced antioxidants such as a-tocopheral, B-carotene, superoxide dismutases and ascorbic acid concentration Zhang (1997). These antioxidants may play a role in the regulation of plant. Moreover, liquid fertilizer containing humic acid increased apple fruit weight, yield and soluble solid content of fruits Li *et al* (1999). Foliar spray with humic acid significantly increased dry weight of plant and green pod yield El-Bassiony *et al* (2010) of snap bean and Khalil *et al* (2012) on hot pepper plants**.**

The aim of the present study was to investigate the effect of different rates of nitrogen fertilizer and humic acid on growth, yield and some physical and chemical properties of hot pepper fruits grown in plastic house condition under sandy soil.

Materials and Methods

Two experiments in plastic house were conducted at Experimental Station of National Research Centre at Nubaria region, North Egypt to study the effect of three concentrations of nitrogenous fertilizer with three levels of humic acid in growth, yield and fruits quality of hot pepper plants in the winter season of 2011 and 2012. The experimental site had a sandy soil texture with pH of 7.6, Ec of 0.19 and the organic matter was 0.21% with

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14.00, 8.90 and 15.60 mg/100g soil of N, P and K respectively. Phosphorus (P_2O_5) and potassium (K_2O_5) were applied 50 and 100 kg/fed. each at the time of soil preparation. Hot pepper seedlings (*Capsicum annuum* L.) cv Beni-Sweif Hybrid F1 was obtained from a local commercial nursery on October 7, 2011 and 2012 seasons respectively. Irrigation was done after sowing when necessary. Six-week-old pepper plants were hand-transplanted into well-prepared beds in the plastic houses. The normal agricultural practices of pepper under drip irrigation system of plastic houses were followed according to the recommendations of Agriculture Ministry. The concentration for nitrogenous fertilizer was urea (46% N) that was split into three equal parts and applied at ten days after transplanting. The other two doses were applied with throe drip irrigation system. The three humic acid levels were sprayed three times during the plants life at 30, 50 and 70 days after transplanting. This experiment included 9 treatments which included all combinations between the three levels of nitrogen fertilizers (25, 50, and 100 kg N/ fed.) with three humic acid concentrations (0, 1g/L and 2g/L). A split plot design with three replicates each was used. Different nitrogen levels were assigned at random in the main plots, while, humic acid concentrations allotted in sub plots.

Measurements:

Each experimental plot area was 6 m^2 (two ridges each was 1 m in width and 3 m in length). At the vegetative growth stage, random samples of five plants from each plot were taken 45 days from transplanting for determination of plant length (cm), number of branches and leaves per plant as well as, leaf chlorophylls contents.

At harvesting time (60 days from transplanting) pepper fruits were picked weekly through the harvesting period for estimation of yield parameters, i.e. number and weight of fruits per plant and total yield per m^2.

For fruit quality determination a random sample of 20 fruits from each plots were taken and the average fruit weight, fruit length and diameter were recorded and also chemical properties of fruit i. e., nitrogen was determined according to Black (1983). In addition, protein percentages in fruits were calculated by multiplying nitrogen content by 6.25. However, ascorbic acid and TSS% were determined according to AOAC (2000). Dry matter of fruits was determined according the method described by Dubois *et al* (1959).

The obtained data of experiments were subjected to the statistically analysis of variance procedure and means were compared using the LSD method at 5% level of significance according to Gomez and Gomez (1984).

Results and Discussion

Vegetative growth characters:

1-Effect of nitrogen levels:

Nitrogen fertilizer application lead to increased plant height at flowering stages (Table 1). The levels of 50 and 100 kg N/ fed. nitrogen fertilizer produced the tallest plants and the shortest plants were formed in the 25 Kg N/fed.. However, these results are good in both seasons. The obtained results were in agreement with others (Bar-Tal, *et al* 2001, Bowen and Frey 2002 and Aminifard *et al* 2012). Height of plant can be considered as one of the indices of plant vigor ordinarily and it depends upon vigor and growth habit of the plant. Soil nutrients are also very important for the height of plants. Therefore, a higher dose of nitrogen increased plant height (Pervez *et al* 2004).

The effect of nitrogen fertilizer on the number of leaves and branches of hot pepper plants were significant (Table 1). The highest number of leaves and branches were obtained at 100 kg N / fed. the obtained results in both two seasons were similar. This was also in agreement with Bar *et al* (2001). The effect of nitrogen fertilizer level on leaf chlorophyll content was significant (Table 1).Results indicated the highest and lowest leaf chlorophyll content were observed at 100 kg N/fed. and 25 Kg N/fed. respectively. These were true in both seasons. A promotion effect of inorganic fertilizers on chlorophyll contents might be attributed to the fact that nitrogen is a constituent of chlorophyll molecule. Moreover, nitrogen is the main constituent of all amino acids in proteins and lipids that act as structural compounds of the chloroplast (Basela and Mahadeen, 2008). Similar results have been reported in investigations conducted by Bowen and Frey (2002), Aroiee and Omidbaigi (2004) and Aminifard *et al* (2012).

2- Effect of humic acid levels:

The effect of foliar fertilizers with humic acid on growth characters was presented in Table (1) revealed that, all doses of humic acid significantly enhanced pepper plant growth characters compared with control. It

appeared also that, the highest significant means of growth characters observed under the highest concentration (2g/ L) compared with the other treatments. Shehata *et al* (2011**)** indicated that**,** humic acid may indirectly impact nutrient uptake through the function of humic acid, and directly impact the plants when they were absorbed by roots. Humic acid promoted the accumulation of reducible sugar which increased wilting resistance through enhancing the osmotic pressure inside plants, enhancement by humic acid of peroxides activity, seed germination, nutrient uptake and root growth were also observed by several researchers e.g. El-Ghozoli (2003) on faba bean plants and El-Desuki (2004) on onion plants reported that growth characters (No. and fresh weight of leaves) were gradually and significantly increased with increasing the level of humic acid application from 0 to 6 L/fed.

Table 1: Effect of nitrogen fertilizer and humic acid foliar application on vegetative growth characters of pepper plants during 2011 and 2012 seasons.

Nitrogen (kg/fed.)	Humic acid levels	Plant length (cm)		Number of				Leaf chlorophyll Mg/g FW	
				Leaves		Branches			
		2011	2012	2011	2012	2011	2012	2011	2012
N 25	0	85.66	88.66	103.6	105.50	7.24	6.81	49.67	48.02
	1g/L	91.93	91.8	109.20	111.77	7.92	6.96	55.72	51.83
	2g/L	98.46	99.1	116.60	117.50	8.00	7.22	53.89	52.71
Mean		92.02	92.16	109.81	111.66	7.72	7.00	53.09	50.85
N 50	0	98.74	98.2	104.7	105.50	7.74	7.55	49.33	49.67
	1g/L	106.10	106.5	113.7	114.50	8.15	7.95	58.43	58.67
	2g/L	106.02	111.3	121.4	117.77	8.58	8.05	57.37	59.00
Mean		103.62	105.3	113.30	112.6	8.15	7.85	55.05	55.78
N 100	0	103.77	103.8	108.5	108.00	8.06	8.40	51.67	57.33
	1g/L	105.17	107.8	117.4	117.73	8.25	8.56	57.40	58.39
	2g/L	108.38	114.3	123.9	123.07	8.59	8.74	60.33	58.73
Mean		105.77	108.2	116.62	116.1	8.30	8.56	56.47	58.15
HA	0	96.05	95.8	105.61	106.3	7.68	7.59	50.22	51.67
	1g/L	101.07	102.0	113.45	114.5	8.11	7.83	57.19	56.30
	2g/L	104.29	108.2	120.66	119.4	8.39	8.00	57.20	56.81
LSD at 5%	N	1.44	1.12	2.86	0.98	0.08	0.12	1.77	3.35
	HA	1.97	1.19	1.61	1.23	0.15	0.05	1.73	2.52
	Inter.	NS	NS	NS	NS	NS	NS	NS	NS

3- Effect of interaction:

Regarding the effect of interaction Table (1) the data of interaction between different nitrogen fertilizer levels and different concentrations of humic acid were not significant responded to the vegetative growth measurements. These results were true in both seasons. The obtained data revealed that, each factor of the interaction act independently on plant growth character of pepper plants.

Table 2: Effect of nitrogen fertilizer and humic acid foliar application on total yield of pepper plants during 2011 and 2012 seasons.

Nitrogen (kg/fed.)	Humic acid levels	Number of fruits /plant		Weight of fruit/ plant (g)		Total yield / m^2	
		2011	2012	2011	2012	2011	2012
N 25	0	66.17	60.28	477.30	458.72	37.09	36.31
	1g/L	71.30	68.52	509.24	495.31	39.29	38.91
	2g/L	76.47	75.02	544.34	547.88	42.55	41.57
Mean		71.31	67.94	510.29	500.64	39.64	38.93
N 50	0	66.51	62.51	541.91	464.80	37.09	36.51
	1g/L	72.79	69.76	586.28	492.94	39.31	38.09
	2g/L	76.01	80.38	618.40	548.29	42.31	41.34
Mean		71.77	70.88	582.20	502.01	39.57	38.64
N 100	0	75.74	65.73	541.82	559.75	45.01	43.73
	1g/L	81.51	71.47	590.74	593.05	46.98	46.25
	2g/L	82.67	75.95	644.29	636.79	48.64	47.54
Mean		79.97	71.05	592.28	596.53	46.87	45.84
HA	0	69.47	62.84	520.34	494.42	39.73	38.85
	1g/L	75.20	69.92	562.09	527.10	41.86	41.09
	2g/L	78.30	77.12	602.34	577.65	44.49	43.48
LSD at 5%	N	1.39	1.53	10.33	7.32	0.97	0.74
	HA	0.98	1.53	7.63	4.51	0.63	0.48
	Inter.	NS	NS	NS	NS	NS	NS

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Total yield of fruits:

1- Effect of nitrogen levels:

Nitrogen fertilizer significantly affected the average fruit weight, fruit numbers and total yield /m^2 (Table 2). Data showed that the highest fruit weight, number of fruit and total yield m^2 were observed from 50 and 100 kg N / fed. treatments while the lowest belonged to the 25 Kg N/fed. These findings are in good accordance with the two experimental seasons. These results are consistent with those reported by Bar *et al* (2001), Magdatena (2003), Akanbi *et al* (2007) and Aujla *et al* (2007) who also reported that increasing the rate of nitrogen fertilizers increases the average fruit weight, number of fruits and total yield of pepper fruits / m^2.Total yield per m^2 was affected by nitrogen fertilizer (Table 2). The highest yield in m^2 was obtained in 46.87 and 45.84 (kg/m^2) in the first and second season respectively after application of 100 kg/fed. The lowest yield was obtained in 39.64 and 38.93 (kg/m^2) in the first and second season respectively at the application of 25 kg of nitrogen application. The marked effect of nitrogen on total yield of fruits per m^2 might be due to the cumulative stimulating effect of nitrogen on the vegetative growth characters Table (1) which form the base for flowering and fruiting. The trend of obtained results are in good accordance of previous investigators such as Tei *et al* (2000), Tumbare *and* Niikam (2004) and Aminifard *et al* (2012) reported that increments in the nitrogen rate of the fertilizers increased the total yield and fruit number of pepper.

2- Effect of humic acid levels:

Spraying plants with humic acid Table (2) revealed that, yield parameters in plots treated with 2g/L humic acid was significantly higher than those in plots receiving 0 or 1g/L humic acid in both seasons. Total yield per m^2 was affected by foliar fertilizers humic acid with 2g/L (Table 2). The highest yield in m^2 was obtained in 44.49 and 43.48 kg/m^2 in the first and second season respectively after foliar application of 2g/L humic acid. The lowest yield was obtained in 39.73 and 38.85 kg/m^2 in the first and second season respectively after foliar application of 0 humic acids. The effect of humic acid on pepper fruit could be attributed to presence of plant growth which are produced by increased activity of micro flora such as fungi, bacteria, yeasts, actinomycetes and algae Arancon *et al* (2004). Humic acid can be also used as a growth regulator to regulate hormone level, improve plant growth, yield and enhance stress tolerance also increasing soil holding capacity when added to the soil Piccolo *et al* (1992). These results were in according with those obtained by El-Bassiony *et al* (2010) of snap bean and Khalil *et al* (2012) on hot pepper plants**.**

3- Effect of interaction:

Results in Table (2) indicated that, the highest value of No. of fruits/ plant and Weight of fruit/ plant as well as the highest total yield /m^2 of hot pepper fruits were recorded by those plants received N at rate of 100 kg/fed. with the highest foliar fertilizers humic acid with 2g/L. However, statistical analysis of the obtained data revealed that no significant differences were found within interaction treatments in both experimental seasons.

Table 3: Effect of nitrogen fertilizer and humic acid foliar application on physical fruits quality of pepper during 2011 and 2012 seasons.

Nitrogen (kg/fed.)	Humic acid levels	Fruit weight (g)		Fruit length (cm)		Fruit diameter(cm)		TSS %	
		2011	2012	2011	2012	2011	2012	2011	2012
N 25	0	5.92	5.95	11.93	11.85	1.59	1.61	3.52	3.48
	1g/L	6.77	6.69	12.39	12.28	1.63	1.57	3.69	3.65
	2g/L	7.07	7.03	12.36	12.43	1.71	1.66	3.79	3.78
Mean		6.59	6.56	12.23	12.19	1.64	1.61	3.67	3.64
N 50	0	6.18	6.11	12.13	12.08	1.63	1.57	3.59	3.57
	1g/L	6.76	6.69	12.65	12.48	1.63	1.59	3.76	3.71
	2g/L	7.16	7.11	12.84	12.51	1.72	1.70	4.15	3.96
Mean		6.70	6.64	12.54	12.36	1.65	1.62	3.83	3.75
N 100	0	6.58	6.54	12.37	12.23	1.61	1.56	3.77	3.67
	1g/L	6.91	6.85	12.46	12.42	1.62	1.58	4.00	3.96
	2g/L	7.83	7.72	12.65	12.55	1.67	1.60	4.19	4.00
Mean		7.11	7.04	12.49	12.40	1.65	1.58	3.98	3.88
HA	0	6.23	6.20	12.14	12.05	1.61	1.57	3.63	3.57
	1g/L	6.81	6.74	12.49	12.39	1.63	1.58	3.82	3.78
	2g/L	7.35	7.28	12.62	12.49	1.69	1.65	4.00	3.91
LSD at 5%	N	0.23	0.16	NS	NS	NS	Ns	0.08	0.05
	HA	0.16	0.17	0.16	0.19	NS	Ns	0.07	0.05
	Inter.	NS	NS	NS	NS	NS	NS	NS	NS

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Physical fruit quality:

1-Effect of nitrogen levels:

As shown in Table (3)**,** significant increments in physical fruit quality i.e. Fruit weight (g), Fruit length (cm), Fruit diameter (cm) and TSS % were noticed with the increase of nitrogen fertilizer level up to 100 kg N/fed. However, hot pepper plants which received nitrogen at the rate of 100 kg N/fed. gave the highest values of fruit weight and TSS% in the two seasons. However, the differences among N levels were statistically significant. On the other hand, fruit length and diameter were not significant in both seasons. These results are consistent with those reported by Bar *et al* (2001), Magdatena (2003), Akanbi *et al* (2007) and Aujla *et al* (2007) who also reported that increasing the rate of nitrogen fertilizers increases the physical fruits of pepper.

2-Effect of humic acid levels:

Table (3) shows clearly that the application of humic acid had a significant effect on its some physical characters of pepper fruits expressed as average fruit weight (g), fruit length (cm) and TSS % of fruit in both two experimental seasons. However, supplying pepper plants by humic acid at level of 2g/L resulted the heaviest physical fruit characters compared to other concentrations. The trends of these results are supported by that of Erik *et al* (2000), El-Desuki (2004) and Khalil *et al* (2012).

3- Effect of nitrogen levels with humic acid:

The resulted data of Table (3) on physical fruit characters of pepper fruits reveals that addition of nitrogen fertilizer level up to 100 kg N/fed. and supplying that plants with humic acid at level of 2g/L gave the heaviest the physical fruit characters. The statistical analysis of the obtained data recorded a nun significant difference within different interaction treatments.

Table 4: Effect of nitrogen fertilizer and humic acid foliar application on chemical fruits quality of pepper during 2011 and 2012 seasons.

Nitrogen (kg/fed.)	Humic acid levels	%						V.c (mg/100g F.W)	
		N		Protein		Dry mutter			
		2011	2012	2011	2012	2011	2012	2011	2012
N 25	0	3.28	3.08	20.50	19.25	10.13	10.59	85.06	88.58
	1g/L	3.32	3.29	20.75	20.57	10.26	10.27	88.12	90.28
	2g/L	3.34	3.31	20.90	20.71	10.66	10.34	91.12	91.72
Mean		3.31	3.23	20.72	20.17	10.35	10.40	88.10	90.19
N 50	0	3.29	3.19	20.59	19.94	10.29	10.42	87.62	90.34
	1g/L	3.33	3.29	20.83	20.56	10.34	10.62	91.11	91.57
	2g/L	3.36	3.40	21.00	21.27	10.26	10.43	93.31	93.15
Mean		3.33	3.29	20.81	20.59	10.30	10.49	90.68	91.69
N 100	0	3.46	3.28	21.65	20.52	10.44	10.34	90.50	91.56
	1g/L	3.51	3.39	21.96	21.21	10.25	10.39	92.42	93.57
	2g/L	3.56	3.58	22.25	22.38	10.29	10.54	92.76	94.37
Mean		3.51	3.42	21.95	21.37	10.33	10.42	91.90	93.17
HA	0	3.35	3.18	20.91	19.90	10.29	10.45	87.73	90.16
	1g/L	3.39	3.32	21.18	20.78	10.28	10.42	90.55	91.81
	2g/L	3.42	3.43	21.38	21.45	10.40	10.43	92.40	93.08
LSD at 5%	N	0.01	0.09	0.03	0.59	NS	NS	1.11	0.70
	HA	0.02	0.04	0.10	0.26	NS	NS	0.81	0.53
	Inter.	NS	NS	NS	NS	NS	NS	NS	NS

Chemical fruit quality:

1-Effect of nitrogen levels:

Data recorded in Table (4) shows clearly that the highest values of N%, Protein % and Ascorbic acid (mg/100g F.W) in hot pepper fruit tissues were determined in fruits of that plants which fertilized by nitrogen at rate of 100 Kg N/fed. the obtained data cleared that with increasing nitrogen fertilizer level, their contents in hot pepper fruit tissues raised to reach the highest values with addition the highest nitrogen rate , i.e. 100 Kg/fed. these findings are in good accordance with the two experimental seasons. However, it is known that increasing the levels of N in soil extract raised the availability of nutrient elements which favored to enhancement their absorption and hence increased its concentration in fruits tissues. Mozafar (1993) reported the positive and negative effects of nitrogen on vitamin C content of fruits, which was disagreement with Anita *et al* (2009) who reported that increasing the rate of nitrogen fertilizers decrease vitamin C content of pumpkin.

2-Effect of humic acid levels:

The application of humic acid Table (4) had a great effect on the value of hot pepper fruit tissues in the two studied seasons. Moreover, increasing rates of the application caused an increment in N%, Protein % and V.C (mg/100g F.W). However, using humic acid at rate of 2g /L resulted highest values of N, protein and VC in two seasons. The statistical analysis of the obtained data show that the differences within different humic acid levels with regard to the studied chemical properties were great reach the 5% level of significant in two seasons, with exception of dry matter content in two seasons. Similar results were obtained by Fagbenro and Agboola (1993), David *et al* (1994), Padem *et al* (1997) and Qawasmi *et al* (1999).

3- Effect of interaction between nitrogen levels with humic acid levels:

The interaction between 3 levels of nitrogen fertilizer and 3 concentrations of humic acid Table (4) had a slow great effect on the several of some chemical nutritional composition of hot pepper fruit tissues. However, pepper plants which received 100 Kg of nitrogen and 2 g/L of humic acid resulted the highest N%, protein % and VC values in two seasons.

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