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EFFECT OF MINERAL NITROGEN SOURCES AND HUMIC ACID APPLICATION ON YIELD AND NUTRIENT CONTENTS OF SEEDS OF CANOLA PLANT GROWN IN MIDDLE SINAI

M. F. Attia
Soil Fertility and Microbiology Department, Desert Research Center (DRC), Cairo

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ABSTRACT: *Field experiments were conducted through two seasons 2009/2010 and 2010/2011 in Middle Sinai, El Maghara Research Station, Desert Research Center, Egypt to investigate the effect of: (1) mineral nitrogen sources, namely ammonium nitrate "AN" and ammonium sulfate "AS", applied in five alternative mixed N-ratios related to 100% of N recommended dose of 60kgNfed^{-1} of AN:AS as follows: (100+0), (75+25), (50+50), (25+75) and (0+100), (2) humic acid (HA), used as foliar spray with HA-solution at concentrations of 0, 2 and 4gL^{-1}, spray rate was 500Lfed^{-1} and (3) the combined effect of mineral N sources and humic acid on biological, straw and seeds yield, seeds oil and protein (content and yield), and content and uptake of nutrients in canola seeds. All parameters (i.e. biological, straw and seeds yield, seeds oil content and yield, seeds protein content and yield and seeds nutrient content and uptake) were often significantly increased with HA spray. Foliar spray with 4gHAL^{-1} gave highest values of such parameters. Ratios of high AS at the expense of AN were superior to those of low AS. Highest values of such parameters were given by the 4thAN:AS ratio. The HA_3 rate (4gL^{-1}) combined with the 4thAN:AS ratio (25%AN+75%AS) surpassed the other combinations and showed the highest values of the yield and seeds content of oil, protein and nutrients. Superiority of 4th N-ratio was particularly shown under HA spray conditions. Superiority of HA_3 was particularly evident under conditions of 50:50 AN:AS ratio. The economic return value for the average of canola seed yield in both seasons due to the (25%AN+75%AS) ratio was higher than that of the other (AN:AS) ratios.*

***Key words**: Nitrogen sources, Humic acids, Canola yield, Oil content, Protein content and Nutrients uptake.*

INTRODUCTION

Canola, family Brassicaceae, is a name applied to edible oil seed rape, which was developed from two species *Brassica napus* and *B. campestris*, and it contains about 40% oil and 23%protein (Downey, 1990). In recent years Egypt is being faced by the problem arising from the shortage in edible oil. The wide gap between production and consumption of edible oil reached 90%, which has created need for importation and/or agricultural expansion in growing oil crops in new locations out of the Nile Valley and Delta.

During the last decade an intensive work has been carried out to grow rapeseed (canola) as an oil crop in Egypt. Canola has the lowest saturated oil content among vegetable oils and thus it would be suitable for diet-conscious consumers (Grombacher and Nelson, 1992). The tender leaves of these canola oil cultivars serve as vegetables and the seed as a source of cooking oil. The residue left after oil extraction being rich in protein is used as fodder for livestock (Khalil *et al*., 1995).

Choosing the correct source and balance of N fertilizers is an important aspect of successful canola production. The problem of the source of fertilizer needs more consideration by researches and in practice (Wiesler *et al*., 1999). In spite of the well-recognized need for N nutrient the chemical composition of the applied fertilizers, is as an important factor in the growth and production of canola.

Muhammad *et al.* (2007) stated that different sources of N fertilizer (i.e. urea, calcium ammonium nitrate and ammonium sulfate) did not show significant differences in oil and seed yield of canola (*Brassica napus* L). Öztürk (2010) found that there were significant differences in canola seed yield, oil and protein content, and other yield components due to N sources and rates; with ammonium sulfate and urea giving higher seed yield than ammonium nitrate.

Canola takes up nitrogen mainly as nitrate and ammonium, but where both are present in soil solution, ammonium uptake is preferred (Bybordi, 2010 and 2011). Work by Lips *et al.* (1990) indicates that combined NH_4^+ and NO_3^- fertilization at an appropriate ratio resulted in greater biomass accumulation compared with plants fed with either nitrogen source alone. Ammonium affects plant development and growth (Britto and Kronzucker, 2002). Addition of NO_3^- to soil was reported by Goyal *et al.* (1982) to alleviate NH_4^+ toxicity. In principle, assimilation of ammonium is simpler than that of nitrate (Hopkins, 1999).

Bybordi (2012) reported that application ammonium nitrate : ammonium sulfate at 50:50 ratio increased canola growth as well as photosynthesis rate. As to nitrogen sources, higher yields were obtained with ammonium sulfate as compared to ammonium nitrate (Rechcigl and Colon, 2000 and Farahbakhsh, *et al.*, 2006).

Oil and protein concentrations in canola seed increase with S fertilization (Malhi *et al.*, 2007). S fertilizer application also improves N-use efficiency and thereby maintained a sufficient oil level and fatty acid quality (Fismes *et al.*, 2000). A 1.5% increase in oil content of seeds of canola (rapeseed) was observed by Laaniste, et al. (2004) due to application of sulfur. Sulphur (S) and nitrogen (N) are closely related, synergistic and of vital importance for plants because S is a major constituent of many amino acids which constitute the building blocks of proteins (Ceccotti, 1996).

Humates seem to have a particular favourable effect on nutrients supply, therefore their application was tested as an approach to improve nutrient balance and plant vitality (Boehme *et al.,* 2005). Foliar spray of these substances also promote growth, and increases yield and quality in a number of plant species (Yildirim, 2007 and Karakurt *et al.,* 2009) at least partially through increasing nutrient uptake, serving as a source of mineral plant nutrients and regulator of their release (Chen and Aviad, 1990 and Atiyeh *et al.,* 2002). Moreover, humates influence the respiration-process, accumulation of sugars, amino acids and nitrate, and make the plants resistant against diseases (Boehme *et al.,* 2005). El-Nemr *et al* (2012) showed that foliar spray of humic acid (HA) led increased plant growth, fruit set and improved production of cucumber; also total contents of N, P, K, Ca and Mg in leaves increased with increasing HA contents in the spray solution (up to 3000mgL^{-1}). Kulikova *et al.* (2005) noticed that humic substances might show anti-stress effects under biotic stress conditions such as unfavourable temperature, salinity and pH.

Keeping in view the importance of N sources and humic acid in affecting yield parameters seeds nutrient contents of canola plant, the present experiments were conducted to study effects of N sources and humic acid application on yield, seed oil content and yield , seed protein content and yield as well as contents as percent and uptake of nutrients in seeds of canola grown in Middle of Sinai, Egypt.

MATERIALS AND METHODS

This study was conducted to determine the effect of nitrogen sources and humic acid foliar application on biological and seed yield, seed oil content and yield, seed protein content and yield and seed nutrient content and uptake of canola (Sero-4) grown in a loamy sand soil through two seasons of 2009/2010 and 2010/2011, in Middle Sinai, El Maghara Research Station, Desert Research Center (DRC), Egypt.

Physical and chemical soil analyses of the experimental site as well as analyses of irrigation water are shown in Table 1. Analyses were accomplished according to Page *et al.* (1982) and Klute (1986).

Besides, the environmental (metrological) data of El-Maghara region, (average of 10 years) are shown in Table 2.

Table 1: Physical and chemical analyses of the experimental soil and irrigation water.

Soil depth (cm)	Available nutrients ($mgkg^{-1}$)							Soil particles distribution (%)			Texture
	N	P	K	Fe	Mn	Zn	Cu	Sand	Silt	Clay	
0 – 30	22	2.17	33	2.59	1.83	0.56	0.24	78.36	14.41	7.23	Loamy sand
30 –60	18	2.43	23	2.79	2.11	0.62	0.29	78.21	13.85	7.94	Loamy sand

Soil depth (cm)	$CaCO_3$ gkg^{-1}	OM gkg^{-1}	CEC cmolc kg^{-1}	pH	EC dSm^{-1}	Water soluble Anion $mmolcL^{-1}$				Water soluble cation $mmolcL^{-1}$			
				Soil paste extract		Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
0-30	117	12	6.2	8.06	1.10	4.50	2.00	4.80	0.30	-	1.2	5.5	4.63
30-60	96	8	8.8	7.98	0.90	4.00	1.50	3.30	0.15	-	1.8	5.2	1.95
Irrigation water				7.26	4.06	8.50	9.29	23.50	0.18	1.00	3.00	27.5	9.97

Notes: Available nutrients extracted by ammonium bicarbonate-DTPA except N which was extracted by 2MKCl

Table 2: Metrological data during short-term (2000 - 2009) mean (STM) and during the two growing seasons of canola in El-Maghara.

Months	STM			1s Season 2009/2010			2nd Season 2010/2011		
	avg. air temp.	R.H. %	Rain mm	avg. air temp	R.H. %	Rain mm	avg. air temp	R.H. %	Rain mm
October	17.0	77.2	5.0	19.9	76.3	3.3	17.6	78.1	2.1
November	17.2	74.8	5.7	20.6	72.6	3.0	17.2	77.5	8.6
December	18.9	73.7	2.2	20.8	73.7	0.0	19.4	71.3	1.2
January	21.1	74.7	0.5	21.7	77.5	0.0	21.3	68.3	0.0
February	23.1	74.4	0.3	24.8	74.7	0.0	23.6	69.1	0.0
March	25.7	73.8	0.0	28.9	77.0	0.0	27.3	64.3	0.0
April	27.7	72.6	0.0	29.5	79.1	0.0	30.6	62.4	0.0
May	28.9	73.5	0.0	32.6	76.4	0.0	30.7	66.1	0.0
June	27.1	72.0	0.0	30.4	74.3	0.0	26.3	66.4	0.0
July	24.9	73.8	2.0	28.2	74.9	0.0	25.1	72.3	0.0
August	22.7	75.9	6.3	21.2	77.2	3.8	22.1	71.3	2.0
September	20.1	75.4	9.2	20.2	77.4	4.5	20.2	70.6	3.3

The experiment was carried out in a randomized complete block design (RCBD) with split plot arrangement consisting of 3 replications. The area of each experimental unit was $13.5m^2$ (2.7m x 5m). The main plots were allocated to foliar spray with HA and the sub-plots were allocated to N-fertilization. Treatments of HA were 0, 2 and $4gL^{-1}$ being the concentration of the spray solution which prepared by dissolved the used rate of HA in tap water at 500 $Lfed^{-1}$. Two sources of mineral N fertilizers namely, ammonium nitrate "AN" (33.5%N) and ammonium sulfate "AS" (20.6%N) which were applied in five alternative mixed ratios at 100% of N recommended dose of $60kgNfed^{-1}$ of AN:AS as follows: (100+0), (75+25), (50+50), (25+75) and (0+100), respectively.

Canola plants were foliar-sprayed five times at 10 day intervals with different concentrations of HA starting after three weeks of planting utilizing a hand-held sprayer. The used HA in this study was in solution of potassium humate having (80% humic acid, 9-11% K, 5-7% moisture, $830Mgm^{-3}$ bulk density, > 98% water solubility). Nitrogen sources and $42kgKfed^{-1}$, as potassium sulfate (41%K) were applied to soil in three equal doses, at sowing, after 3 or 4 of plant leaves formation (i.e. at thinning) and at the beginning of buds flowering, respectively. Before planting, 13kgPfed^{-1}, as ordinary super phosphate (6.8%P) was applied and incorporated in the soil. All agronomic practices were kept uniform and normal for all the treatments.

At harvesting (after about 5months from sowing date) ten random guarded plants were chosen from each replicate and the data of biological yield, straw yield, seeds yield (Mgfed^{-1}) were recorded. Also, crude protein content of the seed was obtained by multiplying N content by 6.25 with N being determined using the Kjeldahl method (A.O.A.C., 2000). Oil content of the seeds was determined by the Soxhlet apparatus with using n-hexane (60°C) as the organic solvent. The yield of oil and protein were determined. The content of phosphorus and potassium in seeds were determined by Wild *et al.* (1985).

All data were subjected to statistical analysis according to Gomez and Gomez (1984). Least significance difference (L.S.D.) at 0.05 probability was applied for comparing means.

RESULTS AND DISCUSSIONS

Concerning the effect of humic acid (HA) foliar application and nitrogen sources (i.e. different ratios of ammonium nitrate "AN" and ammonium sulfate "AS") on yield and seed content of oil protein and nutrients of canola plant grown in middle of Sinai, Egypt, data for the two seasons (2009/2010 & 2010/2011) are discussed.

I. Main effect of humic acid (HA) foliar spray and nitrogen treatments on yield and seed content of oil, protein and nutrients of canola plant:

A) Main effect of humic acid (HA) on yield and seed content of oil, protein and nutrients of canola plant:

1) Biological (straw+seeds), straw and seeds yields:

Data in Table 3 show that there were no significant differences between the HA_1 and HA_2 rates regarding their effect on yield of biological and straw. However there were significant differences between these two rates and the HA_3 rate, which gave the highest averages of 5.394, 3.857 and 1.492Mgfed^{-1} for yields of biological, straw and seed, respectively. However, the lowest average values of 4.143, 2.899 and 1.244Mgfed^{-1} for yields of biological, straw and seed, respectively, were due to the HA_1 rate (the no-spray treatment). Almost similar trends were shown in the 2nd season.

2) Seeds oil and protein content:

Data of canola seed oil and protein contents (Table 4) indicate that there were no significant differences between the 1st and 2nd rates of HA. The HA_3 rate showed the highest averages of seed oil content (42.38%) and protein content (24.62%). The lowest averages of oil content (42.14%) and protein content (23.86%) were due to the HA_1 rate (the no-spray treatment). Almost similar trends were shown in the 2nd season.

3) Oil and protein yield:

Data in Table 5 indicate that significant differences were recorded between all the three HA rates, regarding their effect on the oil and protein yield. The highest averages for yield of oil (0.632Mgfed^{-1}) and yield of protein (0.369Mgfed^{-1}) were given by the HA_3 rate. The lowest averages for yield of oil (0.525Mgfed^{-1}) and protein (0.299Mgfed^{-1}) was obtained due to the HA_1 rate. Almost similar trends were shown in the 2nd season.

4) Seeds nutrients content:

Data in Table 6 indicate that there were no significant differences between the rates of HA_1 and HA_2, regarding their effect on seed nutrients content (i.e. N, P & K%). The HA_3 rate showed the highest seed content of nitrogen (4.07%), phosphorus (0.78%) and potassium (2.54%).

The lowest contents of nitrogen (3.62%), phosphorus (0.70%) and potassium (2.27%) were due to the HA_1 rate. Almost similar trends were shown in the 2nd season.

Table 3: Effect of humic acid (HA) and nitrogen sources (AN:AS)* application on yield of canola plant:

Parameters		Biological yield in Mgfed^{-1}**				Straw yield in Mgfed^{-1}				Seeds yield in Mgfed^{-1}			
		Season 2009/2010											
Humic acid gL^{-1} (H) / N-sources (N)		0	2	4	Mean	0	2	4	Mean	0	2	4	Mean
*AN+AS% (N)	100+0	3.097	4.063	4.463	3.874	2.060	2.893	3.220	2.724	1.037	1.170	1.243	1.150
	75+25	4.150	4.263	4.667	4.360	2.973	2.916	3.287	3.059	1.177	1.347	1.380	1.301
	50+50	4.320	4.317	5.946	4.861	3.093	2.951	4.306	3.450	1.227	1.366	1.640	1.411
	25+75	4.473	4.640	6.570	5.228	3.120	3.187	4.860	3.722	1.353	1.453	1.710	1.505
	0+100	4.677	4.383	5.100	4.720	3.250	3.003	3.613	3.289	1.427	1.380	1.487	1.431
Mean		4.143	4.333	5.349		2.899	2.990	3.857		1.244	1.343	1.492	
LSD0.05		H	N	H×N		H	N	H×N		H	N	H×N	
		0.306	0.395	0.333		0.271	0.350	0.329		0.049	0.064	0.020	
		Season 2010/2011											
*AN+AS% (N)	100+0	3.133	4.082	4.515	3.910	2.058	2.902	3.251	2.737	1.075	1.180	1.264	1.173
	75+25	4.162	4.792	4.948	4.634	2.961	3.431	3.545	3.312	1.201	1.361	1.403	1.322
	50+50	4.712	5.729	6.170	5.537	3.444	4.263	4.473	4.060	1.268	1.466	1.697	1.477
	25+75	5.242	6.233	6.737	6.070	3.885	4.742	4.994	4.540	1.357	1.491	1.743	1.530
	0+100	4.956	5.296	5.401	5.218	3.549	3.885	3.868	3.767	1.407	1.411	1.533	1.450
Mean		4.441	5.226	5.554		3.179	3.845	4.026		1.262	1.382	1.528	
LSD0.05		H	N	H×N		H	N	H×N		H	N	H×N	
		0.308	0.396	0.334		0.273	0.351	0.330		0.051	0.066	0.022	

*AN:AS% = Ammonium nitrate%+Ammonium sulfate% to sum 100% of N recommended dose (60kgNfed^{-1})
** fed = 0.42ha Mg=10^6g Biological= Straw + Seeds

Table 4: Effect of humic acid (HA) and nitrogen sources (AN:AS) application on seeds oil and protein content of canola plant:

Parameters		Seed oil content%				Seed protein content%			
		Season 2009/2010							
Humic acid gL^{-1} (H) / N-sources (N)		0	2	4	Mean	0	2	4	Mean
*AN+AS% (N)	100+0	41.40	41.50	41.80	41.57	22.10	22.40	22.90	22.47
	75+25	41.70	41.70	41.80	41.73	23.00	22.90	23.80	23.23
	50+50	41.80	41.80	42.70	42.10	24.10	23.90	25.90	24.63
	25+75	42.50	43.30	43.30	43.03	25.00	25.70	26.00	25.57
	0+100	43.30	42.70	42.30	42.77	25.10	25.10	24.50	24.90
Mean		42.14	42.20	42.38		23.86	24.00	24.62	
LSD0.05		H	N	H×N		H	N	H×N	
		0.25	0.26	0.27		0.45	0.58	0.79	
		Season 2010/2011							
*AN+AS% (N)	100+0	41.70	42.00	42.00	41.90	22.30	22.70	23.50	22.83
	75+25	42.20	42.90	42.60	42.57	23.00	23.50	24.20	23.57
	50+50	43.00	43.80	43.00	43.27	24.60	24.80	26.10	25.17
	25+75	43.90	43.90	43.60	43.80	25.70	25.80	26.70	26.07
	0+100	43.80	43.30	43.90	43.67	25.80	25.30	24.80	25.30
Mean		42.92	43.18	43.02		24.28	24.42	25.06	
LSD0.05		H	N	H×N		H	N	H×N	
		0.35	0.37	0.38		0.56	0.67	0.70	

* AN:AS% = Ammonium nitrate%+Ammonium sulfate% to sum 100% of N recommended dose (60kgNfed^{-1})

Table 5: Effect of humic acid (HA) and nitrogen sources (AN:AS) application on seeds oil and protein yield of canola plant:

Parameters		Seed oil yield in $Mgfed^{-1}$**				Seed protein yield in $Mgfed^{-1}$			
		Season 2009/2010							
Humic acid gL^{-1} (H) / N-sources (N)		0	2	4	Mean	0	2	4	Mean
*AN+AS% (N)	100+0	0.429	0.485	0.518	0.477	0.229	0.261	0.284	0.258
	75+25	0.491	0.563	0.575	0.543	0.272	0.309	0.328	0.303
	50+50	0.512	0.571	0.701	0.595	0.296	0.327	0.426	0.350
	25+75	0.575	0.630	0.740	0.648	0.338	0.373	0.444	0.385
	0+100	0.617	0.590	0.628	0.612	0.358	0.347	0.365	0.357
Mean		0.525	0.568	0.632		0.299	0.323	0.369	
LSD0.05		H	N	H×N		H	N	H×N	
		0.024	0.031	0.009		0.017	0.021	0.012	
		Season 2010/2011							
*AN+AS% (N)	100+0	0.448	0.496	0.531	0.492	0.240	0.268	0.292	0.267
	75+25	0.507	0.584	0.598	0.563	0.276	0.320	0.338	0.311
	50+50	0.545	0.642	0.730	0.639	0.307	0.353	0.444	0.368
	25+75	0.596	0.655	0.760	0.670	0.344	0.390	0.454	0.396
	0+100	0.616	0.611	0.673	0.633	0.356	0.361	0.386	0.368
Mean		0.542	0.597	0.658		0.305	0.338	0.383	
LSD0.05		H	N	H×N		H	N	H×N	
		0.026	0.032	0.010		0.017	0.022	0.013	

* AN:AS% = Ammonium nitrate%+Ammonium sulfate% to sum 100% of N recommended dose ($60kgNfed^{-1}$)
** fed = 0.42ha $Mg=10^6g$

Table 6: Effect of humic acid (HA) and nitrogen sources (AN:AS)* application on seed nutrient content of canola plant:

		Season 2009/2010											
Parameters		Seeds Nitrogen content (N%)				Seeds Phosphorus content (P%)				Seeds Potassium content (K%)			
Humic acid gL^{-1} (H) / N-sources (N) *		0	2	4	Mean	0	2	4	Mean	0	2	4	Mean
*AN+AS% (N)	100+0	3.53	3.80	4.11	3.81	0.68	0.73	0.79	0.73	2.21	2.38	2.57	2.39
	75+25	3.58	3.85	4.16	3.86	0.69	0.74	0.80	0.74	2.24	2.41	2.60	2.42
	50+50	3.65	3.83	4.02	3.83	0.70	0.74	0.77	0.74	2.29	2.40	2.51	2.40
	25+75	3.69	4.02	4.15	3.95	0.71	0.77	0.80	0.76	2.31	2.51	2.59	2.47
	0+100	3.67	4.01	3.93	3.87	0.70	0.77	0.76	0.74	2.29	2.50	2.45	2.41
Mean		3.62	3.90	4.07		0.70	0.75	0.78		2.27	2.44	2.54	
LSD0.05		H	N	H×N		H	N	H×N		H	N	H×N	
		0.07	0.09	0.13		0.01	0.02	0.02		0.05	0.06	0.08	
		Season 2010/2011											
*AN+AS% (N)	100+0	3.57	3.63	3.7	3.63	0.69	0.71	0.76	0.72	2.23	2.27	2.33	2.28
	75+25	3.68	3.76	3.85	3.76	0.74	0.77	0.78	0.76	2.33	2.35	2.44	2.37
	50+50	3.87	3.85	4.19	3.97	0.77	0.79	0.84	0.80	2.45	2.42	2.63	2.50
	25+75	4.06	4.17	4.18	4.14	0.83	0.86	0.88	0.86	2.54	2.58	2.65	2.59
	0+100	4.05	4.09	4.03	4.06	0.79	0.83	0.82	0.81	2.52	2.55	2.53	2.53
Mean		3.85	3.90	3.99		0.76	0.79	0.82		2.41	2.43	2.52	
LSD0.05		H	N	H×N		H	N	H×N		H	N	H×N	
		0.08	0.010	0.14		0.02	0.03	0.03		0.07	0.06	0.09	

* AN:AS% = Ammonium nitrate%+Ammonium sulfate% to sum 100% of N recommended dose ($60kgNfed^{-1}$)

5) Seeds nutrients uptake:

As shown in Table 7 it can be concluded that that significant differences were recorded between all the three HA rates, regarding their effect on seed nutrients uptake. The HA_3 rate showed the highest uptake of nitrogen ($60.77 kgfed^{-1}$), phosphorus ($11.69 kgfed^{-1}$) and potassium ($37.94 kgfed^{-1}$), whereas, the lowest uptake of nitrogen ($45.16 kgfed^{-1}$), phosphorus ($8.67 kgfed^{-1}$) and potassium ($28.26 kgfed^{-1}$) were obtained with the HA_1 rate (the no-spray treatment). Almost similar trends were shown in the 2^{nd} season.

Conclusive assessment on HA effect:

From the previous data it can be concluded that HA foliar application resulted in an increase in canola seed yield and uptake of N, P and K. These results are in part similar to those obtained by Chen and Aviad (1990); Tattini *et al.* (1991); Atiyeh *et al.* (2002) and Kaya *et al.* (2005), who stated that metabolic changes due to permeability of humic acid into leaf cells to embryonic cells might led to effects demonstrated in the yield and yield components. The stimulating effect of humic acid has been related in part to enhanced uptake of mineral nutrients. Many authors (Chen and Aviad, 1990 and Fagbenro and Agboole, 1993) reported increased uptake of macro and microelements influenced by humic acid substances.

Table 7: Effect of humic acid (HA) and nitrogen sources (AN:AS)* application on seed nutrient uptake of canola plant:

		Season 2009/2010											
Parameters		Seeds N uptake ($kgfed^{-1}$)**				Seeds P uptake ($kgfed^{-1}$)				Seeds K uptake ($kgfed^{-1}$)			
Humic acid%(H) / N-sources (N)*		0	2	4	Mean	0	2	4	Mean	0	2	4	Mean
*AN+AS% (N)	100+0	36.61	44.46	51.09	44.05	7.05	8.54	9.82	8.47	22.92	27.85	31.95	27.57
	75+25	42.14	51.86	57.41	50.47	8.12	9.97	11.04	9.71	26.36	32.46	35.88	31.57
	50+50	44.79	52.32	65.93	54.34	8.59	10.11	12.63	10.44	28.10	32.78	41.16	34.02
	25+75	49.93	58.41	70.97	59.77	9.61	11.19	13.68	11.49	31.25	36.47	44.29	37.34
	0+100	52.37	55.34	58.44	55.38	9.99	10.63	11.30	10.64	32.68	34.50	36.43	34.54
Mean		45.16	52.48	60.77		8.67	10.09	11.69		28.26	32.81	37.94	
LSD0.05		H	N	H×N		H	N	H×N		H	N	H×N	
		2.64	3.41	1.93		0.51	0.658	0.37		1.65	2.13	1.20	
		Season 2010/2011											
*AN+AS% (N)	100+0	38.38	42.83	46.77	42.66	7.42	8.38	9.61	8.47	23.97	26.79	29.45	26.74
	75+25	44.20	51.17	54.02	49.80	8.89	10.48	10.94	10.10	27.98	31.98	34.23	31.40
	50+50	49.07	56.44	71.10	58.87	9.76	11.58	14.25	11.87	31.07	35.48	44.63	37.06
	25+75	55.09	62.32	72.68	63.37	11.26	12.82	15.34	13.14	34.47	38.47	46.19	39.71
	0+100	56.98	57.71	61.78	58.82	11.12	11.71	12.57	11.80	35.46	35.98	38.78	36.74
Mean		48.74	54.10	61.31		9.69	10.99	12.54		30.59	33.74	38.66	
LSD0.05		H	N	H×N		H	N	H×N		H	N	H×N	
		2.66	3.44	1.95		0.53	0.660	0.38		1.67	2.14	1.22	

* AN:AS% = Ammonium nitrate%+Ammonium sulfate% to sum 100% of N recommended dose ($60 kgNfed^{-1}$)
** fed = 0.42ha

B) Main effect of (AN:AS) ratios on yield, oil, and protein and seed nutrient contents of canola plant:

1) Biological (straw+seeds), straw and seeds yield:

Data in Table 3 indicate that the 4th AN:AS ratio (25%AN+75%AS) surpassed significantly with other AN:AS ratios regarding the effect on biological, straw and seed yields, where it showed the highest averages values of 5.228, 3.722 and1.505Mgfed^{-1} for biological, straw and seeds yield, respectively. The lowest averages values 3.874, 2.724 and 1.150Mgfed^{-1} for biological, straw and seed yields, respectively, were due to the 1st AN:AS ratio. Almost similar trends were shown in the 2nd season.

2) Seed oil content:

From data in Table 4, no significant differences occurred between the two ratios 4th and 5th and also between the two ratios 1st and 2nd, regarding their effect on seed oil content However, the former two ratios were significantly different from both the latter two ratios and the 3rd AN:AS ratio. It is worth mentioning that the highest average percent of oil seed content (43.03%) was due to the 4th AN:AS ratio. The lowest percent (41.57%) was due to the 1st AN:AS ratio. Almost similar trends were shown in the 2nd season.

3) Seed protein content:

Results, concerning seed protein content in Table 4, show that significant differences were obtained between the five ratios of applied nitrogen sources. The 5th and 3rd ratios were not significantly different from each other. The 4th ratio showed the highest average of seed protein content (25.57%), however, the lowest average value (22.47%) was obtained at the 1st AN:AS ratio. Almost similar trends were shown in the 2nd season.

4) Oil and protein yield:

Data in Table 5 indicate significant differences between most of the five AN:AS ratios. The 4th AN:AS ratio significantly surpassed the other ratios where it showed the highest average of oil yield (0.648Mgfed^{-1}) and average of protein yield (0.385Mgfed^{-1}). The lowest average of oil yield (0.477Mgfed^{-1}) and average of protein yield (0.258Mgfed^{-1}) was recorded with the 1st AN:AS ratio. Almost similar trends were shown in the 2nd season.

5) Seeds nutrients content:

Significant differences were recorded between most of the five ratios of the applied nitrogen sources (Table 6), with respect to their effect on seeds nutrients content%. The 4th ratio showed the highest seeds content of nitrogen (3.95%), phosphorus (0.76%) and potassium (2.47%), however, the lowest content of nitrogen (3.81%), phosphorus (0.73%) and potassium (2.39%) was obtained at the 1st AN:AS ratio. Almost similar trend was showed in the 2nd season.

6) Seeds nutrients uptake:

Data in Table 7 show that significant differences were obtained between most of the five AN:AS ratios, regarding their effect on the nitrogen, phosphorus and potassium uptake. The 4th AN:AS ratio (25%AN+75%AS) significantly surpassed the other AN:AS ratios where it showed the highest uptake of nitrogen (59.77kgfed^{-1}), phosphorus (11.49) and potassium (37.34kgfed^{-1}) however, the lowest uptake of nitrogen (44.05), phosphorus (8.47kgfed^{-1}) and potassium (27.57kgfed^{-1}) was recorded with the 1st AN:AS ratio (100%AN+0%AS). Almost similar trend was showed in the 2nd season.

Conclusive assessment on mineral N-sources effect:

These results are almost similar with those obtained by Fismes *et al.* (2000); Rechcigl and Colon (2000); Farahbakhsh, *et al.* (2006); Malhi *et al.* (2007) and Öztürk (2010) and Bybordi (2012). In this concerning, previous investigations indicated that effects of N sources on the oil content of canola were significant. Oil and protein content obtained from AS fertilization was higher than that of the other N sources and can be attributed to its content of S

(24%), because S plays an important role in the chemical composition of seed and increases the percentage of oil and protein content of seed (Khan *et al.*, 2002). N fertilization without S was reported to have reduced oil and protein yield due to the decrease in yield (Joshi *et al.*, 1998).

In this respect, ammonium sulfate (AS) fertilizer, was reported by Kacar and Katkat (2007) to be which is physiologically acidic, is more efficient than Ammonium nitrate (AN) especially in alkaline soils containing $CaCO_3$. The $CaCO_3$ content in soil of the experiment was (117gkg^{-1}). AS is different from the other N source of AN where it contains sulfur and which is important soil fertility factor to consider when growing canola (Franzen, 1997). Sulfur requirements for canola are higher than most other crops (Fismes *et al.*, 2000).

C)The combination and interaction effects between humic acid and N-ratios on yield, oil, and protein and seed nutrient contents of canola plant:

1) Biological (straw+seeds), straw and seeds yields:

Regarding the combined effect of the HA rates with the N-ratios on biological, straw and seeds yield of canola plant (Table 3), it can be concluded that the highest average of values 6.570, 4.860 and 1.710Mgfed^{-1} for biological, straw and seeds yields, respectively, were due to the HA_3 rate (4gL^{-1}) combined with the 4th N-ratio (25%AN+75%AS). The lowest average of values (3.097, 2.060 and 1.037Mgfed^{-1}) for biological and straw yield, respectively, were due to the interaction of the HA_1 rate (the no-spray) with the 1st N-ratio (100% AN + 0% AS). Almost similar trends were shown in the 2nd season. The interaction effect between HA and N-ratios shows the followings: (1) superiority of the HA_3 over the other HA treatments occurred particularly in presence of 50:50, 25:75 or 0:100 AN:AS ratios. (2) superiority of the 25:75 ratio over the N-ratios occurred under conditions of HA spray and not where no HA was sprayed.

2) Seeds oil content:

The highest average of seed oil content (43.30%) was shown by the HA_2 rate with the 4th AN:AS ratio. The lowest average of seed oil content (41.40%) was obtained with the HA_1 rate (the no-spray) and the 1st AN:AS ratio (Table 4). Almost similar trends were shown in the 2nd season. The interaction effect between HA and N-ratios shows that HA_3 rate (4gL^{-1}) was higher than the HA_1 and HA_2 rates particularly under conditions of 50:50 AN:AS ratio. On the other hand, the 25:75 N-ratio was the highest particularly where HA was sprayed. The interaction effect between HA and N-ratios was rather similar to that regarding the oil content.

3) Seeds protein content:

The highest average of seed protein content (26.00%) was obtained by the HA_1 rate with the 4th AN:AS ratio. The lowest percentage (22.10%) of seed protein content was due to the HA_1 rate with the 1st AN:AS ratio (Table 4). Almost similar trends were shown in the 2nd season.

4) Oil and protein yield:

The HA_3 rate combined with the 4th AN:AS ratio significantly showed the highest yields of oil (0.740Mgfed^{-1}) and protein (0.444Mgfed^{-1}). The lowest yields of oil (0.429Mgfed^{-1}) and protein (0.229Mgfed^{-1}) were given by the HA_1 rate combined with the 1st AN:AS ratio (Table 5). Almost similar trends were showed in the 2nd season.

5) Seed nitrogen content:

The highest seed nitrogen content (4.15%) was obtained by the HA_3 rate combined with the 4th AN:AS ratio (Table 6). On contrary, the lowest percentage (3.53%) of seed nitrogen content was due to the HA_1 rate combined with the 1st AN:AS ratio. Almost similar trend were shown in the 2nd season.

6) Seed phosphorus content:

Results in Table 6 indicate that although no significant differences were due to the combinations of the 3rd with 3rd, 3rd with 4th and 2nd with 3rd of the HA rates with the

AN:AS ratios. The highest percentage (0.80%) of seed phosphorus content was obtained at the combination of the HA_3 rate with the 4th AN:AS ratio. The lowest percentage (0.68%) of seed phosphorus content was given by the HA_1 rate combined with the 1st AN:AS ratio (Table 6). Almost similar trend were shown in the 2nd season.

7) Seed potassium content:

The highest percentage (2.59%) of seed potassium content was obtained by the HA_3 rate ($4gL^{-1}$) combined with the 4th AN:AS ratio (25%AN+75%AS). The lowest percentage (2.21%) of seed phosphorus content was due to the HA_1 rate (the no-spray) combined with the 1st AN:AS ratio (100%AN+0%AS) (Table 6). Almost similar trends were shown in the 2nd season.

8) Seeds nitrogen uptake:

The HA_3 rate combined with the 4th AN:AS ratio showed the highest nitrogen uptake ($70.71kgfed^{-1}$). The lowest nitrogen uptake ($36.61kgfed^{-1}$) was given by the the HA_1 rate combined with the 1st AN:AS ratio (Table 7). Almost similar trends were shown in the 2nd season.

9) Seeds phosphorus uptake:

The HA_3 rate combined with the 4th AN:AS ratio showed the highest phosphorus uptake ($13.68kgfed^{-1}$). The lowest phosphorus uptake ($7.05kgfed^{-1}$) was given by the HA_1 rate combined with the 1st AN:AS ratio (Table 7). Almost similar trend were shown in the 2nd season.

10) Seeds potassium uptake:

The HA_3 rate combined with the 4th AN:AS ratio showed the highest potassium uptake ($44.29kgfed^{-1}$). The lowest potassium uptake ($22.92kgfed^{-1}$) was given by the HA_1 rate combined with the 1st AN:AS ratio (Table 7). Almost similar trends were shown in the 2nd season.

Conclusive assessment:

When applying humic acid substances to young plants some of the humic acid must have been sprayed on to the soil. This may create a synergetic effect during uptake of nutrients by plants from soil (Vaughan and Malcom, 1985 and David *et al.*, 1994) suggesting existence of synergetic effect of combined application of mineral nutrients and humic acid. Another explanation could be that humic acid substances enhanced plant growth (Casenave *et al.*, 1990).

II. The economic return value for the average of canola seed yield in both seasons due to the (AN:AS) ratios from 100% of N recommended dose ($60kgNfed^{-1}$).

Regarding the economic return for canola seed yield in both seasons due to 100% of N recommended dose ($60kgNfed^{-1}$), data in Table 8 indicate that the lowest seed yield ($1.162Mgfed^{-1}$) was if a total cost equal to $537L.E.fed^{-1}$ was produced due to applying N as 100 ammonium nitrate (AN), where, 1kg produced 6.49kg seeds costing 3.00L.E.. Nevertheless, applying N as 100% ammonium sulphate (AS) produced $1.441Mgfed^{-1}$ at total cost of $582L.E.fed^{-1}$, where, 1kg of this ratio produced 4.95kg seeds at cost of 2.00L.E.. On the other hand, the highest seeds yield ($1.518Mgfed^{-1}$) at total cost equal to $571L.E.fed^{-1}$ was achieved due to the 25%AN+75%AS ratio, where, 1kg of this ratio produced 5.77kg seeds at total cost equal to 2.17L.E..

Finally, from the average of seed yield in both seasons, it can be concluded that seed yield per fed increased due to the 4th (25%AN+75%AS) ratio by 30.6% and 5.3% compared to the 1st (100%AN+0%AS) and 5th (0%AN+100%AS) ratio, respectively. Besides, the total cost of canola seed yield per fed at the 4th (AN:AS) ratio increased only by 6.3% compared to the 1st (AN:AS) ratio, but decreased by 1.9% compared with the 5th (AN:AS) ratio. With regard to the cost of seed yield produced from 1kg of (AN:AS) ratios decreased by 27.7% compared with the 1st (AN:AS) ratio, but increased only by 8.5% compared to the 4th (AN:AS) ratio.

Table 8: The economic return value for the average of canola seed yield in both seasons due to the (AN:AS) ratios from 100% from N recommended dose ($60kgNfed^{-1}$).

Ammonium Nitrate (AN) (33.5%N)			Ammonium Sulfate (AS) (20.6%N)		
%	kg	Price (L.E. *)	%	kg	Price (L.E.)
0	0	0	0	0	0
25	45	134	25	73	146
50	90	269	50	146	291
75	134	403	75	218	437
100	179	537	100	291	582
AN+AS			Seeds Mg/fed**	Price (L.E.) kg (AN+AS)	kgseed/ kg (AN:AS)
Ratios	kg/fed	Price (L.E.)/fed			
100+0	179	537	1.162	3.00	6.49
75+25	207	549	1.312	2.65	6.34
50+50	235	560	1.444	2.38	6.14
25+75	263	571	1.518	2.17	5.77
0+100	291	582	1.441	2.00	4.95

*L.E. = Egyptian Pound **fed= 0.42ha

Conclusion

It can be concluded that the biological, straw and seed yields, seeds oil content and oil yield, seeds protein content and protein yield, and seed nutrients content and uptake of canola plant were often increased either with foliar application of humic acid or with increasing the ratio of ammonium sulfate (AS) at the expense of ammonium nitrate (AN), within the limit of nitrogen recommended dose ($60kgNfed^{-1}$) of canola crop, mostly till the 4^{th} AN:AS ratio (i.e. 25%AN+75%AS). The interaction HA_3 rate ($4gL^{-1}$) combined with the 4^{th}AN:AS ratio (25%AN+75%AS) surpassed the other treatment combinations and showed the highest values of all the abovementioned parameters of canola plant. Also, results indicate that the economic return value for the average of canola seed yield in both seasons due to the (25%AN+75%AS) ratio of N recommended dose ($60kgNfed^{-1}$) was higher than that of the other (AN:AS) ratios.

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تأثير إضافة مصادر النيتروجين المعدنى وحامض الهيوميك على المحصول ومحتوى العناصر الغذائية لبذور نبات الكانولا النامى في وسط سيناء

محرم فؤاد عطية

قسم خصوبة وميكروبولوجيا الأراضى – مركز بحوث الصحراء – المطرية – القاهرة– مصر

المخلص العربي

قد أجريت هذه التجربة لدراسة تأثير مصادر النيتروجين المعدنى (نترات الامونيوم (AN) + كبريتات الامونيوم (AS) والإضافة الورقية لحامض الهيوميك والأثر المشترك لكل منهما على المحصول ومحتوى العناصر الغذائية لبذور نبات الكانولا النامى في وسط سيناء ، محطة بحوث المغارة ، جمهورية مصر العربية ، خلال

الموسمين٢٠٠٩ /٢٠١٠ ، ٢٠١٠ / ٢٠١١. ونفذت هذه التجربة بتصميم القطع المنشقة مرة واحدة حيث كانت مستويات حامض الهيوميك (٠ ، ٢ ، ٤جم/لتر) بمعدل رش ٥٠٠لتر/فدان فى القطع الرئيسية أما نسب كبريتات الامونيوم (AS) إلى نترات الامونيوم (AN) (فى حدود الجرعة الموصى بها من النيتروجين (٦٠كجم/فدان) ، وهى ١٠٠ + ٠ ، ٧٥ + ٢٥ ، ٥٠ + ٥٠ ، ٢٥ + ٧٥ ، ٠ + ١٠٠٪ من نترات الامونيوم (AN) + كبريتات الامونيوم (AS)على الترتيب فقد وضعت فى القطع تحت الرئيسية.

وقد تم تقديرالإنتاجية (المحصول البيولوجى ، محصول القش ، محصول البذور ، ومحتوى البذور من الزيت والبروتين والنيتروجين والفوسفور والبوتاسيوم). وقد ازدادت هذه المقاييس بشكل معنوى غالباً عند الرش بحامض الهيوميك حيث أعطى الرش بحامض الهيوميك عند المعدل الثالث (٤جم/لتر) أعلى القيم لهذه المقاييس. كما أعطت نسب مصادر النيتروجين المعدنى المحتوية على نسبة أكبر من AS ونسبة أقل من AN القيم الأعلى لهذه لمقاييس حيث أعطيت أعلى القيم عند النسبة (٢٥%AN + ٧٥%AS). وقد تفوق الرش بحامض الهيوميك عند المعدل ٤جم/لتر جنباً إلى جنب مع إضافة النسبة (٢٥%AN + ٧٥%AS) من مصادر النيتروجين المعدنى وأعطى أعلى القيم من للإنتاجية ولمحتوى البذور من الزيت والبروتين والعناصر الغذائية مقارنة بالتوليفات الأخرى. وكان تفوق النسبة الرابعة من مصادر النيتروجين المعدنى أكثر وضوحاً عند الرش بحامض الهيوميك HA ، كم ان تفوق المعدل الثالث من الرش بحامض الهيوميك (٤جم/لتر) اكثر وضوحاً عند إضافة النسبة الثالثة من مصادر النيتروجين المعدنى (٥٠%AN+٥٠%AS).

وبدراسة العائد الاقتصادى لمتوسط إنتاجية بذور نبات الكانولا وإضافة النسب المختلفة من مصادر النيتروجين المعدنى فى كلا الموسمين تبين أن أعلى عائد إقتصادى كان عند إضافة النسبة الرابعة (٢٥%AN+٧٥%AS) مقارنة بالنسب الأخرى.