Response of Cabbage Plants (*Brassica oleraceae* var. *capitata* L.) to Fertilization with Chicken Manure, Mineral Nitrogen Fertilizer and Humic Acid

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ABSTRACT

Response of cabbage plants to different rates of chicken manure (00, 10 and 20 m³/fed.), levels of mineral N (00, 60 and 120 kg N/fed. as ammonium nitrate) and humic acid foliar treatments (0, 1 and 2 g/l) as well as their interactions was studied at the Experimental Station Farm, Faculty of Agriculture, Alexandria University during two growing seasons of 2007/2008 and 2008/2009. The obtained results indicated that application of 20 m³/fed. of chicken manure showed more superior effect on vegetative growth characters (plant weight, non wrapper leaves weight and number, as well as total head yield and its component (net head weight, head length and diameter), and N content of inner edible leaves. Addition of 120 kg N/fed. mineral N fertilizer increased plant weight, head weight, head diameter and total head yield; increased N content and decreased total sugar content of inner leaves. Foliar application of humic acid improved plant weight, stem diameter, total head yield and its component (head- weight, length and diameter). Nitrogen content of inner edible leaves was also increased while total sugar content was decreased. Application of the highest rate of chicken manure (20 m³/fed.) combined with the highest level of mineral N (120 kg N/fed.) or humic acid (2 g/l) was found to be favorable for the cabbage to express their best performance on plant weight, net head weight and total head yield. In general, the obtained results reflected high response of cabbage plants cv. "Brunswick" for fertilization with organic and mineral N fertilizers with humic acid, reflected as promoted plant growth and increased head yield and quality under the conditions of the present study.

Key words: Cabbage, chicken manure, inorganic N, humic acid, head yield and quality.

INTRODUCTION

Cabbage (*Brassica oleraceae* var. *capitata* L.) is one of the most important and widely cultivated winter cruciferous leafy vegetables in Egypt. The cultivated area was 42942 Feddan (18036 ha) in 2005 year. Most of this area (11396 ha) was cultivated in the winter season, 3662 ha in summer season and 2977 ha in fall season (Ezzo *et al.*, 2008). It is grown for its compact heads, which have high nutritional value and contain organo-sulphur phytochemicals that increase their antioxidant capacity, which may have anticarcinogenic effects (Kim *et al.*, 2004).

Cabbage is a heavy feeder crop, requires a high rate of N for growth and head yield development. The amount and source of N fertilizer used for this crop varied in various regions of Egypt; for instance, 33.5 up to 134 kg N/fed. as ammonium nitrate at Assiut (Farghaly, 1990), 30 up to 120 kg N/fed., as urea, ammonium nitrate and ammonium sulphate, at Kafr El-Sheikh (Moustafa *et al.*, 1992), 40 up to 120 kg N/fed., as urea, at Gharbia (El-Shabraway, *et al.*, 1999), 20 up to 80 kg N/fed., as ammonium sulphate, at Mansoura (El-Afifi, *et al.*, 2002) and 56 up to 84 kg N/fed., as ammonium sulphate, ammonium nitrate and urea, at El-Bostan (Ezzo *et al.*, 2008); depending on plant cultivar, soil and climatic conditions. Heavy application of organic manure eliminates the necessity for heavy N side-dressings and reduces amount of chemical fertilizer that must be applied and therefore there is a need to use with care, especially in the last half to third of the growing season (Peck, 1981). The greatest benefit of organic manure for cabbage fertilization seems to be the slow release and availability of N which is utilized by cabbage plants efficiently throughout its long growth period (Muhammad *et al.*, 2007).

Organic manure like poultry or chicken manure improve the soil structure, aeration, slow release nutrient and increase water holding capacity which support root development leading to higher yield and better quality of several *Brassica* species like summer cabbage (Smith and Hadley, 1988), broccoli (Abou El-Magd *et al.*, 2006) and cauliflower (Abdel-Razzak and El-Nasharty, 2008 and Abdel-Razzak, *et al.*, 2008).

Humic acid is a product contains many elements which improve the soil fertility and increase the availability of nutrient elements by holding them on mineral surfaces and, consequently, affect plant growth and yield (Hartwigson and Evans, 2000, Hafez, 2004 and Akinci *et al.*, 2009). Nowadays, it is mostly used to eradicate or decrease the negative effects of chemical fertilizers and some other chemicals from the soil (Salman *et al.*, 2005). Poor agricultural practices, particularly N fertilization treatments could interrupt

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growth and result in poor head quality; i.e., unwrapped heads or loose head formation, expose the product to be economically useless in the commercial vegetable markets. Therefore, the current work was undertaken to study the efficiency of using chicken manure in conjunction with mineral N and humic acid applications on improving vegetative growth characters, head yield and its component, as well as to investigate their interaction effects on head quality and some chemical constituents of cabbage cv. "Brunswick".

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Station Farm, Faculty of Agriculture, Alexandria University during the two following seasons of 2007/2008 and 2008/2009, to explore the influence of organic and mineral N, and humic acid fertilization as well as their interactions on vegetative growth, head yield and quality of cabbage plants cv. "Brunswick".

While preparing the field, soil samples (0-25 cm) depth was obtained for chemical analysis (Page, 1982) of the two experimental sites. These samples were analyzed for soil texture, organic matter, available N, P, K, and pH and EC (Table 1).

Organic N fertilizer source and rates:

Chicken manure used was obtained from the Experimental Poultry Station, Faculty of Agriculture, Alexandria University. The physical and chemical properties of the chicken manure are shown in Table (2). The quantity of chicken manure used is divided into two rates; 10 and 20 m^3/fed. in addition to control treatment (without any addition of manure). These two rates represented 68 and 135 kg N/fed. The chicken manure rates were incorporated and mixed carefully with the surface soil layer (0-20 cm), one week before planting Table (3).

Table 1. Some physical and chemical analyses of both experimental sites

Soil properties	2007/2008	2008/2009
Texture	Clay loam	Clay loam
Organic matter (%)	1.8	2.0
N (mg/100gm)	47	28
P (mg/100gm)	10	7.7
K (mg/100gm)	53	45
***pH**	7.4	7.1
****EC (dSm.$^{-1}$)**	1.77	1.96

* measured in 1:25 soil water suspension.
** measured in the water extract of saturation soil paste.

Table 2. Some physical and chemical analyses of chicken manure used in the two growing seasons

Manure characteristics	2007/2008	2008/2009
Moisture content (%)	40	35
Weight of 1m³ (kg)	470	350
Ash (%)	37	14
Organic mater (%)	63	86
Organic carbon (%)	37	50
Nitrogen (%)	1.44	1.93
C/N ratio	15:1	15:1
***pH**	7.8	6.9
***Total dissolved salts (%)**	0.34	0.24
Macro-nutrient (%)		
****P**	2.05	1.80
K	1.3	1.1
Ca	0.34	0.51
Mg	0.12	0.10
Na	0.40	0.17
Micro-nutrient (ppm)		
Fe	14.9	20.3
Mn	5.2	23.2
Zn	9.9	20.0
Cu	5.5	17.0

* (1:10 w:v) chicken manure : water ratio.
** Total P content was determined using wet digestion (Isamu, 1972).

Table 3. Dates and rates of chicken manure application, transplanting date, levels of mineral N application, dates and rates of mineral N and humic acid applications, and first and last harvest of cabbage "Brunswick" cultivar in the two growing seasons of 2007/2008 and 2008/2009

Planting season	Dates and rates of chicken manure applications		Trans-planting date	Levels of mineral N NH4NO3 (kg N/fed.)	Dates and rates of mineral N applications (kg N/fed.)		Dates and rates of humic acid foliar applications (g/l)		Harvest date	
	m^3/fed.	kg N/fed.			First	Second	First	Second	First	Last
		12 Nov.			28 Dec.	2 Feb.	8 Jan.	10 Feb.		
									30	12
2007/2008	00	00	20	00	00	00	0	0	Mar.	Apr.
	10	68	Nov.	60	20	40	1	1		
	20	135		120	40	80	2	2		
		18 Nov.			4 Jan.	15 Feb.	2 Feb.	5 Mar.		
									14	15
2008/2009	00	00	25	00	00	00	0	0	Apr.	May
	10	68	Nov.	60	20	40	1	1		
	20	135		120	40	80	2	2		

Inorganic N fertilization:

Ammonium nitrate (NH_4NO_3, 33.5% N) fertilizer was used at two levels (60 and 120 Kg N/fed.) in addition to zero level as a control treatment. According to cabbage growth pattern, it is an initial slow-growing crop that takes up 1/3 N in its first part of growth (40-60 days from planting); and, approximately, two-thirds of the absorption of nutrients and dry weight production occur during the last part of the growing period; i.e., the final 50 to 60 days preceding harvest (Welch *et al.*, 1985). Therefore, total amount of the assigned N-fertilizer was side-dressed in two different applications, 1/3 of the N fertilizer dose was added at 35 days after transplanting and the remaining of 2/3 N was added at 70 days after transplanting of cabbage plants (Table 3). The mineral N fertilizer was broadcasted manually after weed control, then the soil was immediately irrigated. Moreover, 100 kg fed.$^{-1}$ of each of superphosphate (18.5% P_2O_5) and potassium sulphate (48.0% K_2O) were broadcast-applied to the all experimental plots. Phosphate fertilizer was added as a basal dose during soil preparation; whereas K fertilizer was applied after four weeks from planting.

Humic acid application:

Potassium humic acid granules were mixed with water and sprayed on the plants at the treatment rates; 1 and 2 g/l in addition to zero (control treatment). The control plant was treated with tap water. The applications were executed two times at 30 and 60 days from transplanting (Table 3).

Experimental layout:

The experimental layout was a split-split-plots system in a randomized complete blocks design (RCBD) with three replications. Chicken manure applications were arranged as the main plots, and mineral N fertilizer applications were considered as the sub-plots; while, the humic acid treatments were placed in the sub-sub-plots. Each sub- sub- plot consisted of two ridges; each was 4 m length and 75 cm width; with an area of 6 m². A guard ridge was left between each two adjacent main plots.

Healthy transplants of cabbage cv. "Brunswick" (six weeks old) were selected and transplanted on one side of the ridge at 50 cm apart. The transplanting process took place on 20 and 25 of November 2007 and 2008, respectively (Table 3).

During the two growing seasons, weed control was carried out by hand hoeing. Pest control, irrigation and other agricultural practices were achieved whenever they were found necessary and as recommended for the commercial cabbage production.

Individual cabbage plants were harvested on intervals based on general appearance of the head formation (fully expanded, compact and light smooth inner leaves). Plant samples from all treatment combinations were randomly collected from five central plants of the middle two rows.

Data recorded:-

I. Vegetative growth characters:

At harvest, the following characters of five plant samples were measured; plant weight (kg), stem length (cm), stem diameter (cm), non wrapper leaves weight (kg) and non wrapper leaves number.

II. Total yield and its component:

Cabbage plants were dissected to determine the following data; net head weight (kg) after cut non wrapper leaves, head diameter (cm), head length (cm) and total head yield (ton/fed.).

III. Chemical constituents of cabbage leaves:

Each individual head cabbage was divided longitudinally into two equal parts. Only composite samples taken from these parts were used for the determination of total N, total P, total sugar, reducing sugar and dry matter contents, using standard methods of AOAC, (1995).

Statistical analyses:

Data were statistically analyzed using Co-Stat software computer program for statistics (2004). The differences among the means of the experimental treatments were separated by revised LSD test for interpretation of results as explained by Steel and Torrie, (1980).

RESULTS AND DISCUSSION

I- Vegetative growth characters:-

Table (4) clarified the presence of some significant increment on vegetative growth characters of cabbage as a result of increasing chicken manure rates. Application of 20 m^3/fed. gave the highest plant weight, non wrapper leaves- weight and -number in both seasons. However, the detected increments over the other treatments were not great enough to reach the level of significance for both stem- length and -diameter characters. The positive effects of chicken manure on vegetative growth might be attributed to its narrow C/N ratio (15:1) as shown in Table (2), which led to high rates of decomposition and release of sufficient nutrients to be available for the growing plants (Abdel-Razzak and El-Nasharty, 2008), consequently, encouraged the plant growth to go forward. Table (4) revealed that the gradual increment of mineral N application up to 120 kg N/fed. resulted in significant increases of plant weight in both seasons compared with the control. Also, the high values of non

Table 4. Effect of chicken manure, mineral N and humic acid fertilization on some vegetative growth characters of cabbage during the two growing seasons of 2007/2008 and 2008/2009

Treatments	Plant weight (kg)		Non wrapper leaves weight (kg)		Non wrapper leaves number		Stem length (cm)		Stem diameter (cm)	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Chicken man. (m^3/fed.)										
00	2.67b	2.87b	1.01b	0.76b	11.15b	8.59b	12.70a	10.30a	4.41a	2.73a
10	3.11a	3.27a	1.06b	0.95a	11.42b	10.02a	12.93a	9.745a	4.45a	2.83a
20	3.32a	3.52a	1.24a	0.97a	12.82a	10.32a	13.62a	9.934a	4.55a	2.89a
Mineral N (kg N/fed.)										
00	2.86b	2.82b	1.06a	0.85a	11.53a	9.35b	13.65a	9.07a	4.40a	2.68b
60	3.07ab	3.17ab	1.13a	0.88a	11.75a	9.48ab	12.28a	9.85a	4.50a	2.86a
120	3.17a	3.40a	1.15a	0.95a	12.10a	10.10a	13.32a	10.26a	4.50a	2.90a
Humic acid (g/l)										
0	2.69c	2.89c	1.05a	0.82b	11.55a	9.61a	13.24a	10.32a	4.17b	2.61c
1	3.07b	3.17b	1.12a	0.90ab	11.66a	9.65a	13.13a	9.87a	4.51a	2.84b
2	3.34a	3.31a	1.14a	0.97a	12.18a	9.67a	12.89a	9.79a	4.72a	3.00a

Values followed by similar letters, within a comparable group of means, do not significantly differ, using revised LSD test at 0.05 level.

wrapper leaves- weight and -number, and stem- length and -diameter reflected the same trend of increasing; but with significant differences only for non wrapper leaves number and stem diameter in the second season. The detected unpronounced positive effects of N fertilization on the vegetative growth traits might be due to the relatively low available amounts of total N in the used soil, especially in the second season (Table 1). Similar results were obtained by Ezzo *et al.*, (2008), who found that the application of high N level (84 kg N /fed.) significantly increased cabbage plant growth; plant weight and non wrapper leave- weight and -number.

Concerning the effect of humic acid, Table (4) clearly indicated that applying humic acid gave increases on the vegetative growth parameters, particularly plant weight and stem diameter of cabbage plants which reflected highly significant difference in both seasons, compared with the control treatment (without humic addition). The increase in plant weight due to humic acid application might be related to its role in stimulation of plant growth by the assimilation of major and minor elements, enzymes. changes in membrane permeability, protein synthesis and finally the activation of biomass production (Ulukon, 2008).

II- Head yield and its component:-

The results in Table (5) showed clearly that increasing the applied rates of chicken manure up to 20 m^3\fed. led to progressive significant increases in the value of the following characters: head weight and total head yield in both seasons, and head- length and -diameter in the second season, compared with the control. The increase percentages on total head yield by the highest organic N level (20 m^3\fed.), compared with control treatments, were 13.91% and 22.94% in the first and second seasons, respectively. The increment in total head yield, resulting from using organic N might be attributed to that chicken manure enhanced soil-aggregation, -aeration and increasing water holding capacity. In addition, it releases slowly nutrients all over the growth season. These favorable conditions created better nutrients absorption and favors the growth and development of root system which, in turn, reflects better vegetative growth, photosynthetic activity and more dry matter accumulation in growing *Brassica* species (Smith and Hadley, 1988, Abou El-Magd *et al.*, 2006 and Abdel-Razzak, *et al.*, 2008). Consequently, a higher total head yield would be obtained by using chicken manure.

Table (5) showed that mineral N fertilizer at the highest rate (120 kg N\fed.) increased head weight, head diameter and total head yield in both seasons. However, this trend of increment did not reach the significance level for head length trait. The cabbage head yield was significantly increased as mineral N increased up to 120 kg N\fed. with increment percentages of 7.50% and 9.89% in the first and second seasons, in that order relative to control treatments. This result agreed with those obtained by Farghaly, (1990), El-Shabraway *et al.*, (1999) and Ezzo *et al.*, (2008), who reported that application of the highest rate of N (134, 120 and 84 kg N/fed., each in order) gave highly significant increases of cabbage head yield. The increase in head yield might be attributed to the beneficial effect of N on stimulating the meristimic activity for producing more tissues and organs, in addition to its vital contribution in several biochemical processes in the plant, related to growth and yield development (Marschner, 1994).

Foliar application of humic acid at a level up to 2 g\l resulted in highly significant differences for head-weight, -length, -diameter and total head yield in both seasons. The relative increases in total head yield were 19.79% and 26.35%; in the first and second seasons, respectively. It could be concluded that the highest yield and its component were obtained from the plants that received humic acid at the rate of 2 g/l. The superiority of the highest level of humic application might be referred to increased uptake of macro- and micro-elements, influenced by humic substances, in addition to the growth promoting activity of humic substances was found to be caused by plant hormone-like material (cytokinins) contained in the humic substances (Salman *et al.*, 2005), which possibly led to improved growth and yield of cabbage.

III- Chemical composition:-

The effects of different chicken manure rates on N (%), P (%), total sugar (%), reduced sugar (%) and leaves dry matter (%) of cabbage edible leaves are listed in Table (6). Increased chicken manure rates up to 20 m^3/fed. was associated with detected increments on N content of leaves in both seasons. However, the detected differences in P content of leaves appeared significant in the first season only. On the contrary, application of chicken manure reduced the percentages of total sugar and dry matter in cabbage leaves but with an insignificant trend. The positive effect of chicken manure application on N content of leaves was previously reported by Abou El-Magd *et al.*, (2006) in broccoli leaves, and Abdel-Razzak and El-Nasharty, (2008) in cauliflower leaves.

Table (6) showed that application of mineral N fertilizer at the rate of 120 kg N/fed. gave significantly higher mean values of N (%) in cabbage leaves in both seasons. This positive effect could be attributed to the high capacity of the plants supplied with N to build more metabolites and, in turn, increase growth. Similar observation was obtained by El-Sawy *et al.*, (1992) and

Table 5. Effect of chicken manure, mineral N and humic acid fertilization on cabbage yield and its components during the two growing seasons of 2007/2008 and 2008/2009

Treatments	Head weight (kg)		Head length (cm)		Head diameter (cm)		Total head yield (ton/fed.)	
	2008	2009	2008	2009	2008	2009	2008	2009
Chicken man. (m^3/fed.)								
00	1.52b	1.94b	13.73a	13.98b	17.43a	19.13b	25.37b	26.77b
10	1.71a	2.17a	13.76a	14.29ab	17.90a	21.01a	27.82a	31.17a
20	1.80a	2.33a	14.16a	14.74a	18.48a	21.13a	28.90a	32.91a
Mineral N (kg N/fed.)								
00	1.62b	2.04b	13.50a	14.14a	17.60b	19.61b	26.93b	29.03b
60	1.63b	2.18a	13.91a	14.50a	17.91ab	20.74ab	27.77ab	30.73ab
120	1.77a	2.22a	14.23a	14.37a	18.30a	20.92a	28.95a	31.90a
Humic acid (g/l)								
0	1.46c	1.87c	13.49b	13.53c	16.87c	19.09c	25.17c	26.57c
1	1.70b	2.17b	13.91ab	14.45b	18.40b	20.68b	28.33b	30.71b
2	1.86a	2.41a	14.24a	15.02a	18.83a	21.49a	30.15a	33.57a

Values followed by similar letters, within a comparable group of means, do not significantly differ, using revised LSD test at 0.05 level.

Table 6. Effect of chicken manure, mineral N and humic acid fertilization on some chemical components of cabbage inner leaves during the two growing seasons of 2007/2008 and 2008/2009

Treatments	N (%)		P (%)		Total sugar (%)		Reduced sugar (%)		Dry matter (%)	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Chicken man. (m^3/fed.)										
00	1.64c	2.34b	1.02b	0.36a	5.72a	7.03a	2.80a	4.58a	14.20a	12.15a
10	1.73b	2.44b	1.05b	0.36a	5.63a	7.02a	2.60b	4.37a	13.73a	10.28a
20	1.83a	2.73a	1.40a	0.37a	5.65a	6.74b	2.72ab	4.50a	13.58a	10.92a
Mineral N (kg N/fed.)										
00	1.60b	2.41b	1.12a	0.36a	5.83a	7.08ab	2.78a	4.58a	14.55a	11.28a
60	1.76a	2.49ab	1.15a	0.36a	5.63ab	7.0ab	2.63b	4.47a	12.85a	11.00a
120	1.84a	2.61a	1.21a	0.36a	5.54b	6.71b	2.70ab	4.38a	14.02a	11.07a
Humic acid (g/l)										
0	1.65c	2.28b	1.11a	0.35a	5.81a	7.09a	2.73a	4.73a	13.99a	11.64a
1	1.76b	2.54a	1.17a	0.36a	5.63b	6.91ab	2.71a	4.45b	13.83a	10.77b
2	1.80a	2.68a	1.21a	0.37a	5.55b	6.79b	2.68a	4.26c	13.70a	10.95ab

Values followed by similar letters, within a comparable group of means, do not significantly differ, using revised LSD test at 0.05 level.

El-Shabrawy *et al.*, (1999), who found that increasing the level of N fertilizer up to 120 kg N/fed. increased N content of cabbage edible leaves. The results in Table (6) illustrated also that application of N fertilizer with successive amounts, caused some significant decrease in total sugar. Such a result could be referred to increased moisture content of leaves as a result of increasing N levels.

Applying humic acid, in general, showed significantly higher contents of N in the cabbage leaves, compared with control treatment. This superiority might be attributed to the role of humic acid on plant growth, particularly on plant metabolic, and/or its role on improving soil structure. Furthermore, humic acid is rich in the organic and mineral substances, which are essential for plant growth and that keep soluble fertilizers in root zone more available as needed.

IV- Interactions effect between different fertilizer treatments on cabbage yield and its component:-

Figures (1-4) illustrated the interaction effects of the first order between (chicken manure x mineral N), (chicken manure x humic acid) and (mineral N x humic acid) on some vegetative growth, and head yield and its component, as well as N content of cabbage plants. In both seasons, significant difference in plant weight, non wrapper leaves weight, non wrapper leaves number, head weight and total head yield were detected from the comparisons among the means of the 9 treatment combinations between the different chicken manure rates and mineral N levels (Fig. 1). The application of the highest rate of chicken manure (20 m^3/fed.) combined with high level of mineral N (120 kg N/fed.) gave the highest significant mean values for plant weight, head weight and total yield. Such a result might be contributed to the ability of mineral N (ammonium nitrate) to accelerate organic N decomposition. Actually, the rapid decomposition of complex organic substances into less complex compounds, which are subsequently transformed into low molecular weight organic elements, allows more elements to be utilized by the plants (Montemurro *et al.*, 2008).

The interaction effects between chicken manure rates and humic acid treatments are presented in Fig. (2). The statistical analysis of the obtained data revealed that the treatment combinations had significant effects on total head yield and its component in both seasons. The application of 20 m^3/fed. chicken manure combined with foliar application of humic acid (2 g/l) was favorable for the plants to express their best performance on plant weight, head weight and total head yield. The combined enhancing effect of chicken manure and humic acid on plant growth and head yield might be attributed to that humic substances will maximize the efficient use of soil plant nutrients and help in release those plant nutrients presently bound in minerals and salts. These results are in agreement with Hafez, (2004) and El Ghamry *et al.*, (2009).

The interaction effects between the different rates of mineral N fertilizer and humic acid treatments on vegetative growth, and head yield and its component characters, Fig.(3) reversed generally that the application of N fertilizer combined with humic acid in successive amounts, in both seasons, resulted in steady corresponding increases with significant differences on plant weight, head weight and total head yield. On the other hand, the differences among the values of non wrapper leave weight and non wrapper leave number were not found high enough to be significant. It could be concluded that the best cabbage head yield and its component were obtained by treating the plants with 120 kg N/fed. and 2g\l of humic acid as a foliar application, Such a positive effect could be attributed to the high capacity of the cabbage plants, supplied with a sufficient amount of N nutrient by both sources of fertilizers (ammonium nitrate and potassium humic acid), to build more metabolites and, in turn, increase growth and head yield (Zebarth *et al.*, 1991).

The first order interaction effects, among the different rates of organic- and mineral -N fertilizers, and humic acid, on N content of cabbage inner leaves are presented in Fig. (4). The application of the highest rate of chicken manure (20 m^3/fed.) combined with the highest level of mineral N (120 kg N/fed.) or combined with the highest rate of humic acid (2 g/l), as well as the highest level of mineral N (120 kg N/fed.) combined with the highest rate of humic acid (2 g/l) caused a significant increase on N content in inner leaves. This superiority might be attributed to that humic acid which is rich in the organic and mineral substances, essential for plant growth, and can keep soluble fertilizers in root zone to be more available (Hafez, 2004). Also, it might be attributed to the availability of N derived from mineral and organic N application for the growing plants during early and late stages of growth.

Table (7) indicated the presence of the second order interaction effects among chicken manure, mineral N fertilizer and humic acid treatments. The differences among the mean values of the various treatment combinations of total head yield and its component; *viz.* plant weight, head- weight, -length and -diameter were found significant. The best treatment combination appeared to be that of using 20 m^3/fed. of chicken manure + 120 kg N/fed. of ammonium nitrate and 2g\l of humic acid, which resulted in the highest mean values for plant weight (3.88, 4.05 kg), head weight (2.29, 2.70 kg), head diameter (19.88, 22.77 cm), head length

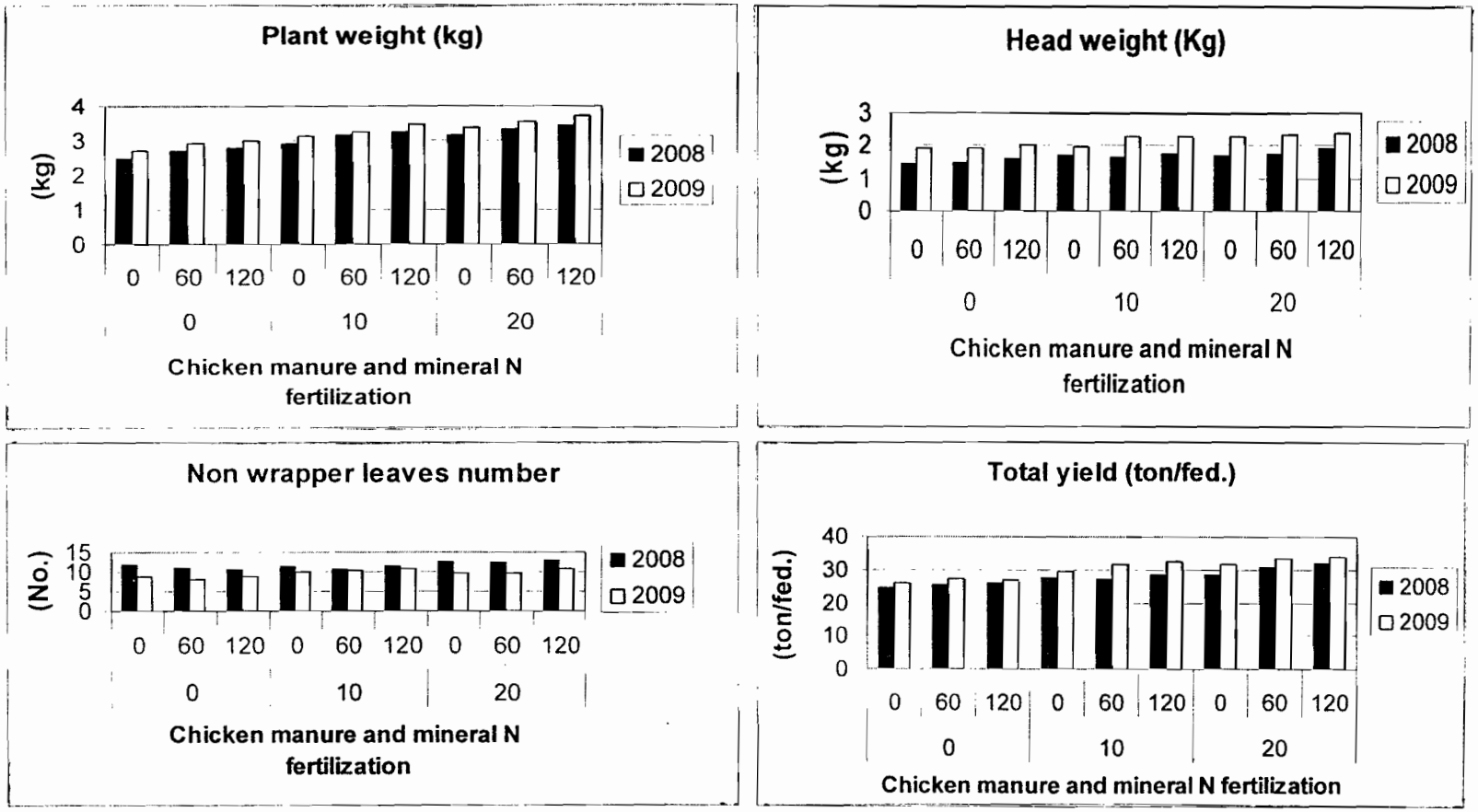

Fig. 1. Interaction effect of the first order between chicken manure x mineral N fertilizer on some vegetative growth and total yield of cabbage plants during the two growing seasons of 2008 and 2009

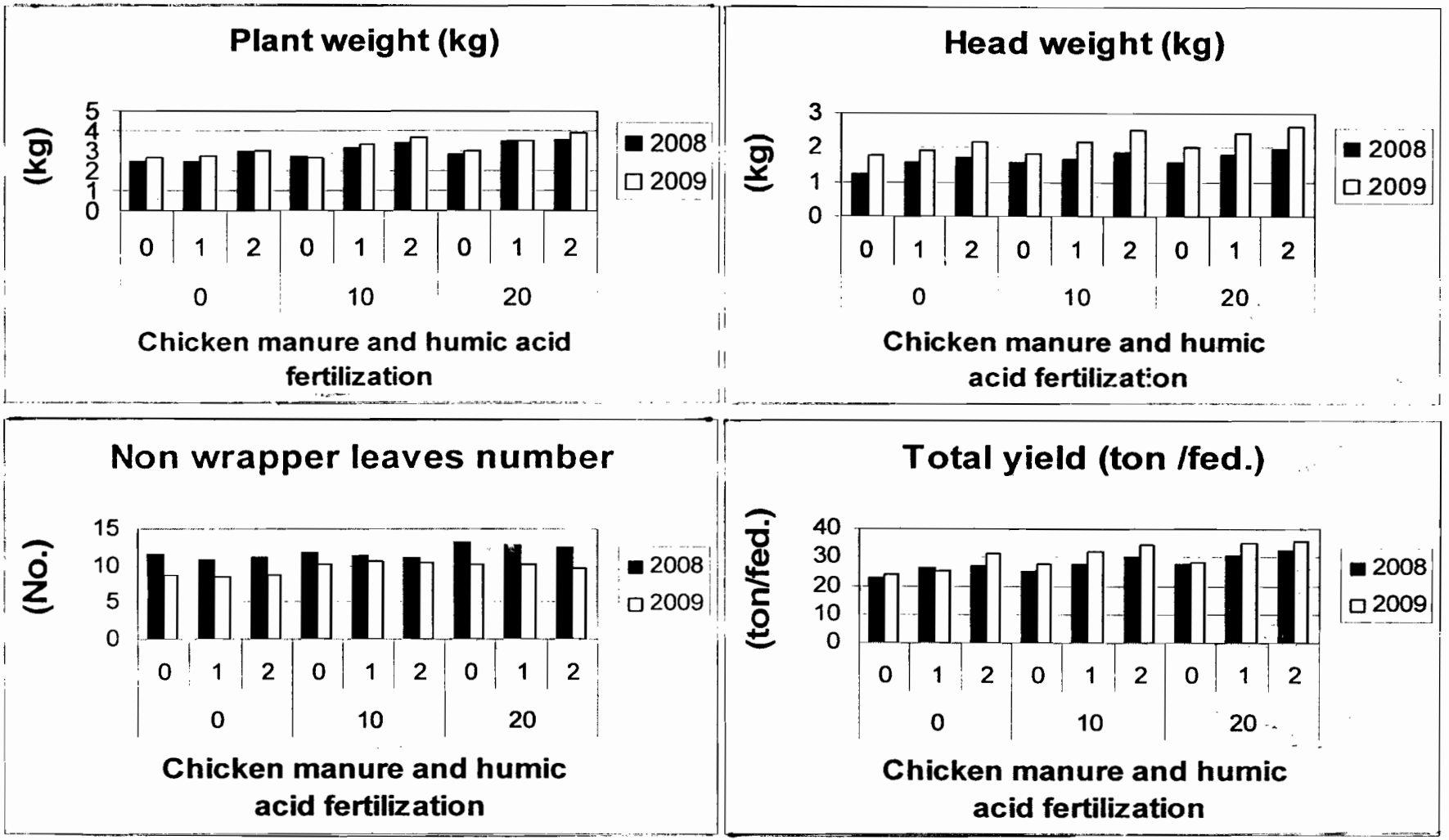

Fig. 2. Interaction effect of the first order between chicken manure x humic acid fertilizer on some vegetative growth and total yield of cabbage plants during the two growing seasons of 2008 and 2009

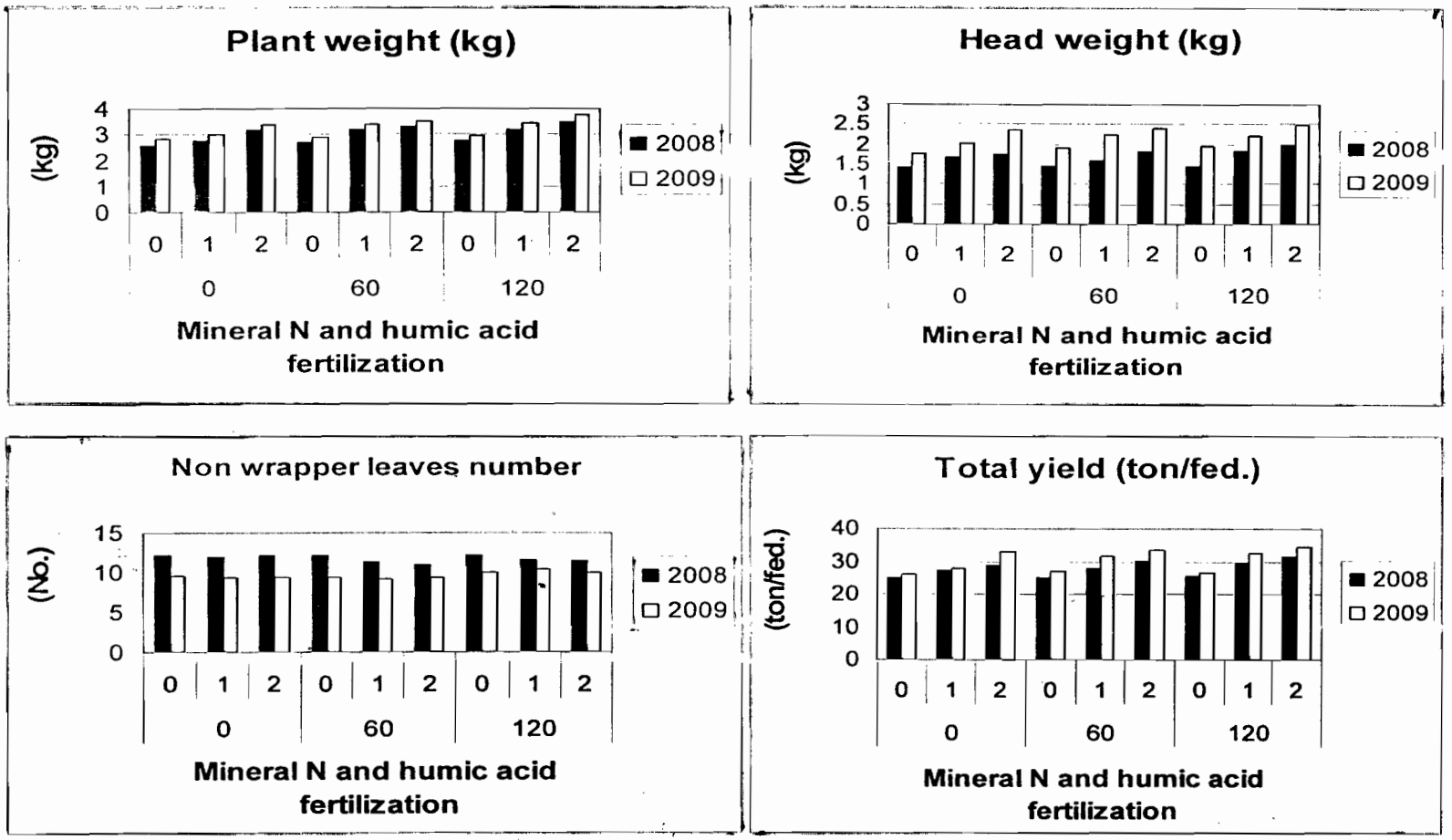

Fig. 3. Interaction effect of the first order between mineral N x humic acid fertilizers on some vegetative growth and total yield of cabbage plants during the two growing seasons of 2008 and 2009

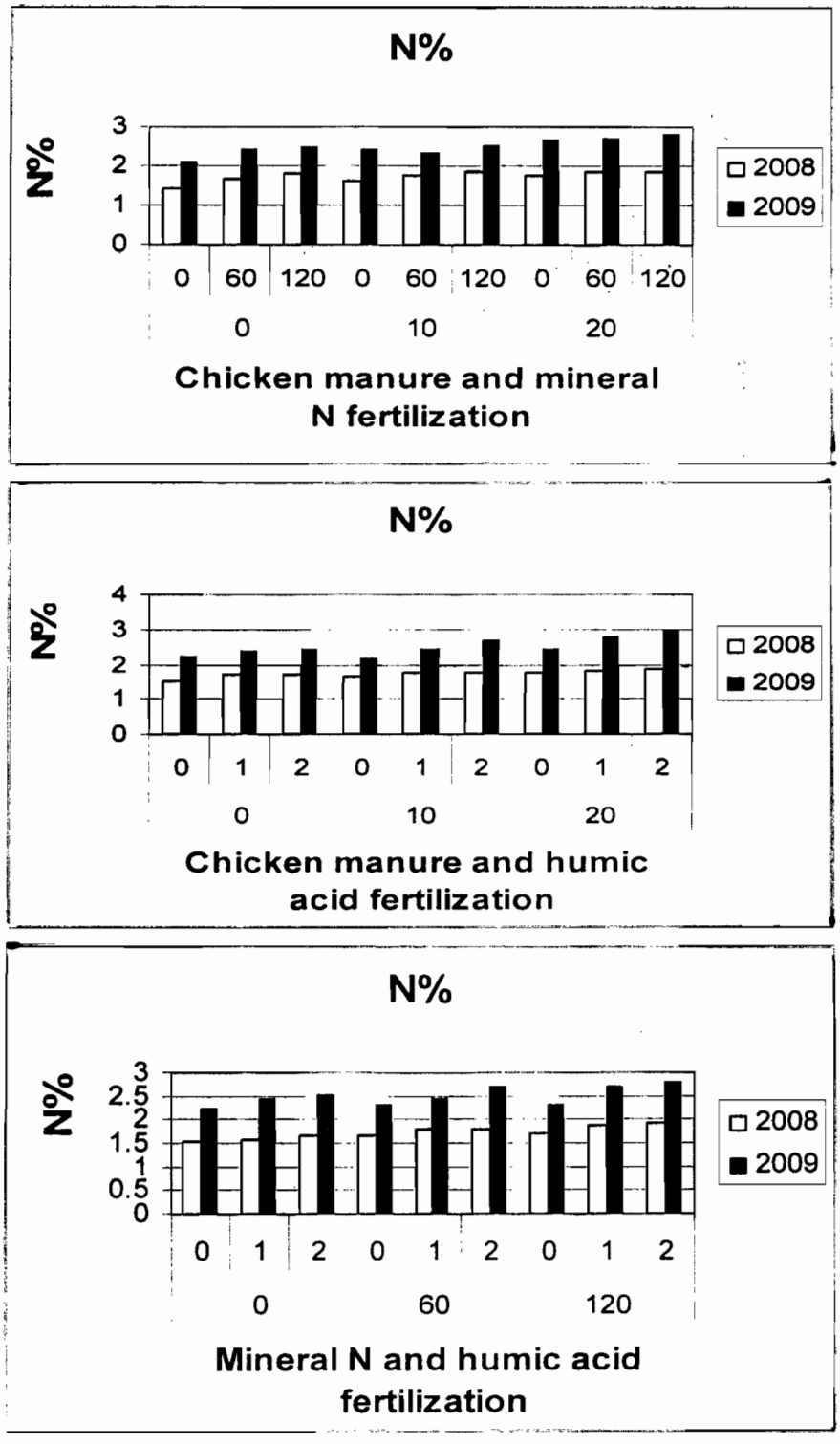

Fig. 4. Interaction effect of the first order between chicken manure x mineral N, chicken manure x humic acid and mineral N x humic acid fertilization on N content of cabbage inner leaves during the two growing seasons of 2008 and 2009

Table 7. Effect of chicken manure, mineral N and humic acid fertilization on cabbage yield and its component during the two growing seasons of 2007/2008 and 2008/2009

Treatments			Plant weight (kg)		Head weight (kg)		Head length (cm)		Head diameter (cm)		Total head yield (ton/fed.)	
Chic. man. m³/fed.	Min. N kg N/fed.	H.A. g/l	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
00	00	0	2.34k	2.54k	1.21h	1.61h	13.22 bc	13.11g	16.61g-i	16.22k	22.00k	23.46h
		1	2.62h-k	2.82h-k	1.47e-h	1.89f-h	13.83a-c	14.00b-g	16.90f-i	17.22jk	25.63h-k	24.42f-h
		2	2.86d-k	3.01d-k	1.63b-g	2.16b-g	14.08a-c	14.00b-g	17.97b-h	18.78g-j	25.86d-k	30.51gh
	60	0	2.44jk	2.64jk	1.22h	1.80gh	14.11a-c	13.22fg	16.80g-i	18.44h-j	23.20jk	25.09e-h
		1	2.80f-k	3.00f-k	1.58c-g	1.90f-h	13.72a-c	14.11b-g	17.55c-i	20.11d-h	26.4f-k	25.66d-h
		2	3.15b-h	3.33b-h	1.72b-f	2.11b-h	13.88a-c	15.67a	18.16b-g	21.33a-d	27.06b-h	31.08a-h
	120	0	2.71g-k	2.91g-k	1.31gh	1.89f-h	14.16a-c	13.18fg	16.50hi	18.33ij	22.59g-k	24.59d-h
		1	3.36a-e	3.56a-e	1.71b-f	1.98d-h	13.27bc	13.89c-g	17.83ci	20.18c-g	26.96a-e	26.38c-h
		2	3.46a-c	3.62a-c	1.81b-d	2.14b-g	13.55a-c	14.69a-f	18.55a-e	21.55a-d	28.73a-c	31.81a-h
10	00	0	2.50jk	2.70jk	1.54d-h	1.63h	13.27bc	13.33e-g	16.33i	20.11d-h	25.95jk	26.26d-h
		1	2.75g-k	2.93g-k	1.77b-e	1.89f-h	13.16bc	14.39a-g	17.66c-i	21.22a-e	27.66g-k	28.06b-h
		2	2.82e-k	3.03e-k	1.83bd	2.34a-f	13.72a-c	14.77a-e	18.70a-d	21.44a-d	29.33ek	33.65a-g
	60	0	2.56i-k	2.76i-k	1.57c-g	1.9f-h	13.20bc	14.78c-g	16.50hi	20.22c-g	24.26j-k	27.56b-h
		1	3.32b-d	3.51b-d	1.42f-h	2.42a-e	13.66a-c	14.61a-g	18.16b-g	21.55a-d	26.76b-d	33.22a-h
		2	3.63a-c	3.82a-c	1.89bc	2.54a-c	13.50a-c	14.89a-d	18.80a-d	21.89a-c	30.26a-c	34.07a-f
	120	0	3.08c-i	3.27c-i	1.57c-g	1.97d-h	13.22bc	13.55d-g	17.00e-i	20.22c-g	26.13c-i	29.05a-h
		1	3.40a-d	3.62a-d	1.81b-d	2.23a-g	14.83a-c	14.33a-g	18.50a-f	21.44a-d	28.63a-d	33.83a-f
		2	3.53a-c	3.73a-c	1.96ab	2.60ab	15.50a-c	15.00a-d	19.50ab	22.10ab	31.36a-c	34.81a-e
20	00	0	2.58i-k	2.75i-k	1.57c-g	2.05c-h	13.00c	14.00b-g	16.86g-i	19.33f-i	26.90i-k	28.68b-h
		1	2.90d-j	3.12d-j	1.77be	2.29a-g	13.44a-c	14.55a-g	18.52a-e	20.66b-f	28.36a-j	31.58a-h
		2	2.82e-k	3.01e-k	1.85bd	2.55a-c	13.80a-c	15.10a-c	18.83a-d	21.55a-d	30.66e-k	34.62a-e
	60	0	2.63g-k	2.84g-k	1.56c-g	2.00d-h	13.44a-c	13.77c-g	17.44d-i	19.44f-i	27.40g-k	28.26b-h
		1	3.38a-d	3.59a-d	1.81b-d	2.43a-e	14.58a-c	15.00a-d	18.75a-d	21.66a-d	30.70a-d	36.31a-d
		2	3.69ab	3.87ab	1.87b-d	2.55a-c	15.16ab	15.44ab	19.05a-c	21.99ab	33.86a-c	36.36a-c
	120	0	3.18b-g	3.38b-g	1.57c-g	1.95e-h	13.83a-c	13.88c-g	17.83c-i	19.55e-i	28.16b-g	28.26b-h
		1	3.48a-c	3.65a-c	1.95ab	2.47a-d	14.75a-c	15.22a-c	19.16a-c	22.11ab	33.83a-c	36.58ab
		2	3.88a	4.05a	2.29a	2.70a	15.50a	15.67a	19.88a	22.77a	34.20a	36.98a

Values followed by similar letters, within a comparable group of means, do not significantly differ, using revised LSD test at 0.05 level.

(15.50, 15.67 cm) and total head yield (34.20, 36.98 ton/fed.) of cabbage plants cv. "Brunswick" in the first and second growing seasons, in that order.

CONCLUSION

It can be concluded that the heaviest tonnages of cabbage yield, having the heaviest plant- and head - weight, and the biggest head size (head length and diameter) were correlated by fertilization with high amounts of used different sources of N (chicken manure, mineral N and humic acid).

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الملخص العربي

استجابة نباتات الكرنب للتسميد بزرق الدواجن والسماد الآزوتي المعدني وحامض الهيوميك

جيهان عبد العزيز الشرقاوي وهشـــام عبد الرزاق صالح

استجابة نباتات الكرنب لمعدلات متباينة من زرق الدواجن (صفر-١٠-٢٠ مترا مكعبا/فدان) ومستويات من النيتروجين المعدني (صفر-٦٠- ١٢٠كجم ن/فدان في صورة نترات الأمونيوم) و معاملات الرش بحامض الهيوميك (صفر-١- ٢جرام/لتر) وكذلك تأثير التداخلات بينهما تم دراستها خلال الموسمين الزراعيين لعامي ٢٠٠٧/٢٠٠٨ و٢٠٠٨/٢٠٠٩ بمحطة البحوث الزراعية التابعة لكلية الزراعة جامعة الإسكندرية.

توضح النتائج التي تم الحصول عليها الآتي:

- إضافة ٢٠ مترا مكعبا/فدان من سماد زرق الدواجن أظهرت تأثيرا متميزا علي صفات النمو الخضري (وزن النبات- وزن الأوراق غير الملتفة وعددها) وكذلك محصول الرؤوس الكلي ومكوناته (وزن الرأس الصافي-طول الرأس- قطر الرأس) ومحتوي الأوراق الداخلية من النيتروجين الكلي.
- إضافة١٢٠كجم نيتروجين/فدان من السماد الآزوتي المعدني أدت إلي حدوث زيادة في وزن النبات- وزن الرأس- قطر الرأس- محصول الرؤوس الكلي بالإضافة إلي زيادة محتوي الأوراق الداخلية من النيتروجين الكلي وانخفاض محتواها من السكريات الكلية.
- معاملة الرش الورقي بحامض الهيوميك حسنت وزن النبات- قطر الساق- محصول الرؤوس الكلي ومكوناته (وزن الرأس- طول الرأس- قطر الرأس). محتوي الأوراق الداخلية من النيتروجين الكلي ازداد أيضا بينما انخفض محتوي هذه الأوراق من السكريات الكلية.
- إضافة المعدل المرتفع من سماد زرق الدواجن (٢٠مترا مكعبا/فدان) مشتركا مع المستوي المرتفع من السماد الآزوتي المعدني (١٢٠كجم نيتروجين/فدان) أو مع المستوي المرتفع من حامض الهيوميك (٢جرام/لتر) هي الأفضل للكرنب لكي تظهر الأداء المرغوب علي وزن النبات ووزن الرأس ومحصول الرؤوس الكلي.

وتشير نتائج الدراسة الي الاستجابة المرتفعة لنباتات الكرنب صنف "برونزويك" للتسميد بالأسمدة الآزوتية العضوية والمعدنية مع حامض الهيوميك منعكسة علي تشجيع نمو النبات وزيادة محصول الرؤوس وجودته تحت ظروف هذه الدراسة.